Effect of quicklime and limestone on microbial activity in agricultural soils

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meinen Eltern

Christine und Erich

und allen meinen

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Acknowledgments

Jede Masterarbeit trägt die Handschrift des Erstellers
und dennoch ist sie niemals die Arbeit eines Einzelnen.

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Abstract

High input of mechanical energy in agricultural practice can negatively affect soil structure and decrease soil pore space. This further impairs the water- and air permeability and restricts the habitat of soil organisms. A promising approach to improve soil compaction is the addition of polyvalent ions like Ca^{2+}, which can be added in form of quicklime and limestone. However, quicklime may lead to a strongly alkaline pH in the soil, which could affect the microbiology. In this study, a greenhouse pot experiment was conducted using quicklime and limestone to examine their effects on microbial parameters over time. Silty and clayey soils from three different locations in Austria were sampled and incubated with the applied liming materials for three months (application rate: 2000 kg ha^{-1}). Soil samples were taken two, 30 and 86 days after application of CaO and $CaCO_3$ to assess microbial effects. Parameters such as pH, extracellular hydrolytic and oxidative enzyme activities, phospholipid fatty acids (PLFAs), microbial biomass carbon and nitrogen, dissolved organic carbon (DOC) and nitrogen, nitrate and ammonium were determined. Initially, soil pH and DOC were strongly increased by quicklime. However, after the second sampling, the pH values of all tested soils returned to levels comparable to the soils treated with limestone, and the DOC values declined continuously during incubation period. Microbial biomass increased slightly at the end of the experiment in the quicklime treatments. Most microbial results showed an immediate inhibition effect of quicklime on potential hydrolytic enzyme activities and an increase in oxidative enzyme activities. These effects were less pronounced in the medium term. In summary, the results suggest that the application of quicklime has only short-term impacts on most microbial parameters.

Kurzfassung

Hohe mechanische Belastung auf landwirtschaftlich genutzten Flächen kann sich negativ auf die Bodenstruktur auswirken. Eine Möglichkeit zur Stabilisierung der Bodenstruktur ist der Zusatz von mehrwertigen Ionen wie Ca^{2+}, die beispielsweise in Form von Branntkalk und Kalksteinmehl zugesetzt werden können. Allerdings kann die Branntkalk-Zugabe zu einem stark alkalischen pH-Wert im Boden führen, was die Bodenmikrobiologie beeinträchtigen könnte. Es wurde ein Glashausversuch angesetzt um die Wirkung von Branntkalk und Kalksteinmehl auf mikrobielle Parameter zu untersuchen. An drei Standorten in Österreich wurden schluffig-tonige Böden beprobt und nach Zugabe von Branntkalk bzw. Kalksteinmehl für drei Monate inkubiert (Applikationsrate: 2000 kg ha^{-1}). Die Beprobung für die mikrobiologischen Bestimmungen erfolgte zwei, 30 und 86 Tage nach der Applikation, um die Parameter im Zeitverlauf zu untersuchen. Der pH-Wert, extrazelluläre hydrolytische und oxidative Enzymaktivitäten, Phospholipid-Fettsäuren (PLFAs), mikrobieller Biomasse-Kohlenstoff und -Stickstoff, gelöster organischer Kohlenstoff (DOC) sowie Nitrat und Ammonium wurden gemessen. Die Applikation von Branntkalk bewirkte anfänglich deutlich erhöhte pH- und DOC- Werte, welche sich im Laufe des Versuchs aber wieder reduzierten. Die mikrobielle Biomasse nahm unmittelbar nach der CaO-Applikation ab, erhöhte sich aber leicht am Ende des Versuches. Hinsichtlich der Enzymaktivitäten hatte die Applikation von Branntkalk eine Inhibierung der hydrolytischen Enzyme zufolge, während die oxidativen Enzyme verstärkt produziert wurden. Diese Effekte waren allerdings nach knapp 3 Monaten nicht mehr ausgeprägt. Zusammenfassend zeigen die Ergebnisse, dass die Anwendung von Branntkalk nur kurzfristige Auswirkungen auf die meisten mikrobiellen Parameter hatte.

Content

1. Tables & Figures

2. Introduction

Global population has been growing by 1 billion every 12 to 14 years since 1960 (D'Odorico et al., 2014) and thereby continuously rises the demand for food production on our planet by 59-98 % between 2005 and 2050 (Valin *et al.*, 2014). To cope with these agricultural challenges in many regions, there is an ongoing trend from traditional small scale farming to large scale farming (Paul *et al.*, 2004; Chapoto *et al.*, 2013). Present agriculture has intensified yields by high inputs of industrial fertilizer and modern technologies (heavy processing machines; Tilman *et al.*, 2011; Chapoto *et al.*, 2013; D'Odorico *et al.*, 2014). Fertilizers are used to increase nutrient availability to plants (Marschner *et al.*, 2003). However, large quantities of nitrogen fertilizers result in a base cation depletion and is remarkably responsible for a decrease of soil pH (Tian and Niu, 2015). However, soil acidity is a limiting factor for plant growth by affecting physical, chemical, and biological properties of soil (Fageria and Baligar, 2008). Heavy processing machinery used for agricultural operations (Nawaz et al., 2013) as well as high density of livestock cause high risk of soil compaction (Beylich *et al.*, 2010). Although, also natural processes such as tree roots, precipitation and seasonal cycles can cause compaction (Nawaz *et al.*, 2013), and the soil type has a large impact (Batey, 2009). Usually natural processes impact the upper soil layer (5 cm), while animal trampling and anthropogenic forces results in soil compaction up to 20 cm. Mechanical development leads to compaction up to 60 cm of soil (Nawaz *et al.*, 2013).
Soil pH as well as soil compaction have a strong influence on soil microbiology (Fageria and Baligar, 2008; Beylich *et al.*, 2010). Soil acidity affects activities of microorganisms and enzymes, which results in a change of decomposition of organic matter, nutrient mineralization and immobilization, and there is an impact on crop yield (Haynes and Swift, 1988; Fageria and Baligar, 2008). Furthermore the soil microbial community reacts to pH (Fierer and Jackson, 2006; Rousk *et al.*, 2009). Soil compaction especially influences the physical properties of soil, increases the bulk density, changes tortuosity and connectivity of soil pores and results in a decrease of macropores (Beylich *et al.*, 2010). Soil compaction results in a decline of the habitat of many soil organisms (Vinther *et al.*, 1999) and further, the water infiltration, hydraulic conductivity, air permeability and – aeration decrease (Beylich *et al.*, 2010). On the other hand, potential for surface water runoff, soil erosion increases and negative effects on plant growth (Beylich *et al.*, 2010) and productivity have been observed (Pupin *et al.*, 2009).

An approach to remediate soil acidity is the application of base cations, like exchangeable Ca^{2+} (Tian and Niu, 2015). An additional advantage of the Ca^{2+} ions can be ascribed to flocculation, which improves aggregate stability (Bauer, 2015). The application of Ca^{2+} ions results in an increase of salt concentration in soil solution and reduces the double layer of soil particles; the newly particles flocculate faster, than the particles with lower Ca^{2+} ion concentrations (Horn *et al.*, 2010). The Ca^{2+} ions can be applied for example, in form of calcium carbonate (“limestone” $CaCO_3$) or calcium oxide ("quicklime" CaO; Horn *et al.*, 2010; Tian and Niu, 2015). CaO reacts with water to calcium hydroxid

[Ca(OH)$_2$]. The solubility product of Ca(OH)$_2$ (5.02 x10^{-6}) is three orders of magnitude higher than that of $CaCO_3$ (3.36 x 10^{-9}; Haynes, 2013) which has the consequence that it reacts much faster. With the application of $CaCO_3$ soil solution pH generally reaches values of 6.9 - 8.2 (in equilibrium with CO_2 in the soil air) but above >10 after the application of CaO.

The application of $CaCO_3$ is a currently known method to reduce soil acidity and CaO is in the UK a common method to improve engineering properties, to improve clayey soils that pose problems for construction (Beetham *et al.*, 2014). However, to my knowledge only few studies examined the effects of different liming materials on soil microbiology (Haynes and Swift, 1988; Bardgett and Leemans, 1995).

To this end we conducted a greenhouse pot experiment, where 2000 kg ha^{-1} CaO and $CaCO_3$ were applied in the upper 7 cm in pots containing three compaction-prone Austrian soils from intensively used fields. Soil samples were taken at three different times (two, 30 and 86 days after application) to test the short- and medium term effect of CaO and $CaCO_3$ application on soil chemical and microbial parameters.

We hypothesized that: (*H1*) Due to the high solubility and the strong increase of pH the application of CaO causes a short-term effect on all microbial parameters. However, $CaCO_3$ is less rapidly soluble and the pH effect is less pronounced, therefore the effect on microbial parameters is less and later. (*H2*) The effect of CaO and $CaCO_3$ is higher in the upper layer than in the lower layer. This is due to the solubility of the amendments, reacting more strongly in the applied layer.

3. Materials and Methods

2.1 Sampling sites

The soil material for the pot experiment was sampled at three different locations in Austria (Lower Austria, Upper Austria, Burgenland). The soil from Lower Austria was sampled on 1st August 2013, continued by the sampling in Upper Austria on the 8th August 2013 and finally on the 12th August 2013 the Burgenland soil was sampled. In order to obtain a representative soil sample and to avoid potential edge effects the material was taken at least 10 m away from the border of the field. For sampling purposes the crop if present needed to be removed on an area of 5 m^2 prior to soil sampling. The upper 15 cm of soil layer were treated with pickaxe and thrown over a sieve riddle (mesh size of ~ 15 mm) to remove stones and larger soil particles. Approximately ~2000 kg of soil from each site was filled into labeled plastic bags for transport. Before filling the pots, the soil material were sieved again (mesh size 10 mm) to get rid of smaller stones and roots and mixed to ensure homogenization.

Lower Austria

The first sampling site, Haag, is located in the community Strengberg (ST) in the west of Lower Austria in the district of Amstetten at an elevation of 346 m asl. The area is located on an upper back slope and is only used for agriculture purposes (maize). The surface showed manganese concretion and rust brown mottles. This area is according to the Austrian electronic soil map (e-bod) as an “extreme Pseudogley” (Bauer, 2015).

Upper Austria

The second sampling site is located in the community Pollham (PO) in Upper Austria in the district Grieskirchen at an elevation of 385 m asl. The area is used for agriculture purposes (wheat) and to e-bod (Bauer, 2015), the soil type is a “typical Pseudogley”.

Burgenland

The third sampling site, Kemeten (KE) in the community Oberwart, is located in the south of Burgenland in the district of Oberwart at an elevation of 315 m asl. The area is used for agriculture purposes (soy bean). The soil type is also a “Pseudogley” (Bauer, 2015).

Table 1 Basic characterization of soils (control after 86 days); values obtained from Technical Bureau Unterfrauner, with permission

parameter	unit	Strengberg	Pollham	Kemeten
C_{org}	%	1.77	1.69	1.31
CEC_{pot}*	mmolc 100 g^{-1}	20.58	12.22	22.04
pH (KCl)	-	6.43	7.63	5.27
electrical conductivity	mS cm^{-1}	0.983	0.720	0.212
$CaCO_3$	%	-	7.1	-
C/N ratio		9.5	10.9	10.4
clay	%	34.2	56.6	9.3
silt	%	26.5	60.7	12.8
sand	%	39.6	32.3	28.2

* potential cation exchange capacity

2.2. Greenhouse pot experiment

At first, 13 holes were drilled into the bottom of each pot (Ø 27.5 cm, height 21.5 cm). The pots were then filled with washed gravel to a height of ~ 2 cm and covered with a filter fleece, to ensure that the water can drain during the entire experiment. Subsequently each pot was filled with ~ 12 kg soil and the pots were moistened from below in a tray filled with water. During the entire experiment the water content was kept at ~ 50 % of the water holding capacity of the respective soil by watering from above. The pots were pre-incubated for one month for equilibration purpose. After equilibration (on the 17th September 2013) the upper soil layer (0-7 cm) of all pots was mechanically treated with a small garden shovel. Followed by quicklime (CaO) and limestone ($CaCO_3$) application (at a rate of 2000 kg ha^{-1}), which was incorporated in the top 0-7 cm with a “garden claw”. Altogether 4 replicates from 3 treatments (CaO, $CaCO_3$, control) for each site were established, resulting in a total of 36 pots for the microbial analyses. To maintain homogeneity the pots were placed in a randomized design, to equally distribute potential effects of inhomogeneous shading, different temperature gradation and differences in aeration.

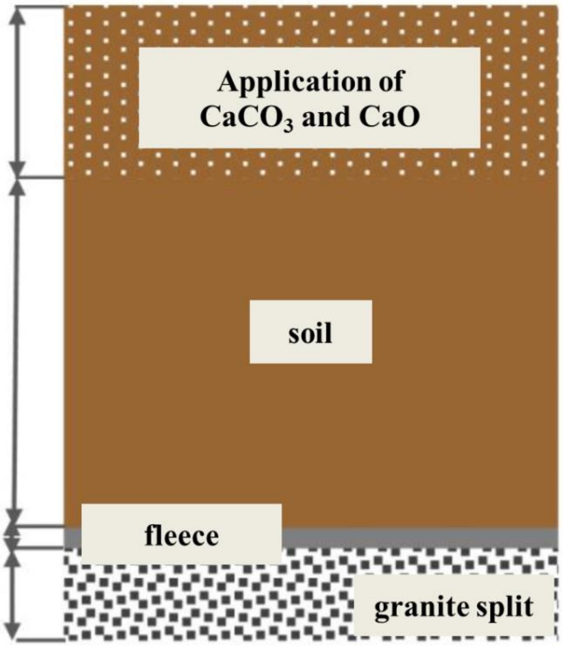

Figure 1 pot composition (Bauer, 2015; Lisa-Maria, 2015)

HA-C-2	ST-C-2	SU-I-2			
ST-I-2	HA-II-2	ST-II-2			
ST-II-3	SU-I-3	HA-I-3			
ST-I-3	ST-C-3	HA-C-3			
SU-C-3	SU-II-3	HA-II-3	ST-II-1	HA-I-1	SU-C-1
ST-I-4	HA-I-4	ST-II-4	ST-I-1	ST-C-1	SU-II-1
SU-I-4	ST-C-4	HA-C-4	HA-C-1	SU-I-1	HA-II-1
SU-II-4	SU-C-4	HA-II-4	SU-C-2	HA-I-2	SU-II-2

Figure 2 randomized block design for the sites Strengberg "ST", Pollham "SU" and Hartberg "HA" in four replicates; control "C", CaO "I" and $CaCO_3$ "II"

2.3. Soil sampling for the microbial analyses

To measure short- and medium term effects on microbial soil parameters three samplings were conducted: 2 days (19th September 2013), 30 days (17th October 2013) and 86 days (12th December 2013) after the application. With a plastic probe (Ø 2.0 cm) four subsamples were taken from 4 different points in the pots. Each core sample was divided into 40 % upper treated layer (0-7 cm) and in 40 % untreated layer (7-14 cm). The center piece (20 %) was eliminated, in order to clearly separate the layers. The four subsamples were combined to one composite sample which was immediately sieved < 2 mm for further analyses.

2.4. Soil Analyses

The soil samples were examined in regard of the following parameters: pH, gravimetric soil water content (%WC), gas fluxes (CO_2), potential enzyme activities (Cellulase, Phosphatase, Chitinase, Protease, Phenoloxidase und Peroxidase-activity), microbial carbon (C_{mic}) and nitrogen (N_{mic}), dissolved organic carbon (DOC), total nitrogen (TN), nitrate-nitrogen (NO_3^-), ammonium-nitrogen (NH_4^+) and phospholipid fatty acids (PLFA).

2.4.1.pH and dry Matter and Water Content (%WC)

pH was determined in 0.01 M $CaCl_2$ solution with a calibrated pH-meter (Mettler Toledo SG23). The sieved soil samples were oven dried for 24 hours at 105°C to determine water content (Schinner *et al.*, 1996).

2.4.2.Mineral nitrogen (N_{min}): nitrate-nitrogen and ammonium-nitrogen; Microbial biomass: Carbon and Nitrogen (C_{mic} and N_{mic}), dissolved organic carbon (DOC) and total nitrogen (TN) – Fumigation Extraction Technique

The soil samples were extracted with the chloroform fumigation extraction CFE as described Schinner et al. (1996). The soil samples were extracted with 1 M KCl in a 1:10 w/v ratio. The extracts were incubated and shaken for one hour at room temperature on a benchtop orbital shaker. According to that the extracts were filtered through Wattmann filter paper (pore size < 2 µm).

Afterwards the ammonium concentration was determined by Berthelot reaction according to Schinner et al. (1996). The nitrate concentration was determined with vanadium chloride, as described in Hood-Nowotny et al. (2010). The absorbance was measured with a plate reader (PerkinElmer® 2300 EnSpire™, China) for ammonium at a wavelength of 660 nm and nitrate at 540 nm. Fumigated and non-fumigated samples (DOC and TN) were measured with an automated TOC/TN analyzer (TOC-V CPHE200V, linked with a TN-unit TNM-1 220 V, Shimadzu Corporation, Kyoto, Japan) according to Brandstätter et al. (2013).

2.4.3.Enzyme activities

To analyze the extracellular enzyme activities fluorimetric and spectrophotometric assays according to Kaiser et al. (2010) were used with minor modifications. An ultrasonic homogenizer (Bandelin, Berlin, Germany) was used to homogenize one g of each soil sample with 100 ml of sodium-acetate buffer (100 mM, pH 5.5). To determine potential activity of cellobiohydrolase ("cellulase" EC 3.2.1.91), N-acetyl-glucosaminidase ("chitinase" EC 3.2.1.52), acid phosphatase ("phosphatase" EC 3.1.3.2), and Leucin-aminopeptidase ("protease" EC 3.4.21) a fluorimetrical measurement was performed with 4-methyl-umbelliferlyl-β-D-cellobioside ("MUF-cellobiosidase"; CAS No.72626-61-0), 4-methyl-umbelliferlyl-N-acetyl-β-D-glucosamine ("MUF-glucosaminide"; CAS No. 37067-30-4), 4-methylumbelliferly-phosphate ("MUF-phosphate"; CAS No.3368-04-5) and L-leucine-7-amido-4-

methyl coumarin ("Leucine-AMC"; CAS No. 62480-44-8) as substrates. These substrates (50 µl) were pipetted into black microtiter plates with 200 µl of soil suspension. Microtiter plates were incubated for 140 min at 20 °C in the dark and then were measured at 450 nm emission wavelengths at an excitation at 365 nm (PerkinElmer® type 2300 EnSpire™).

L-3,4-dihydroxyphenylalanin (DOPA; CAS. No. 59-92-7) was used as substrate for the potential activities of phenoloxidase and peroxidase. Soil homogenates and 20 mM DOPA solution 1:1 were mixed to a final concentration of 10 mM. The samples (250 µl) were pipetted in transparent microtiter plates and were incubated at 20 °C for 20 hours. For peroxidase activity 10 µl of 0.3 % H_2O_2 was added to the samples. The absorption was measured at 450 nm before and after the incubation. The enzyme activities were calculated according to German et al. (2011).

2.4.4.Phospholipid fatty acid analysis (PLFAs)

The soil samples (~ 10 g) were freeze dried for 24 hours (Christ Alpha 1-2 LD Freeze Dryer, Germany). The PLFA analysis is divided into five steps:

Step 1: Lipid extraction modified by Buyer et al. (2010)

Freeze dried soil samples (~ 2 g) were weighed into Pyrex vessels and mixed with 4 ml Bligh-Dyer solution (70 ml methanol (MeOH), 35 ml chloroform ($CHCl_3$) and 28 ml 0.15 M citrate buffer with pH 4.4) and 10 µl internal standard (methyl-tridecanoate). An ultrasonic homogenizer (Bandelin, Berlin, Germany) was used to homogenize this mixture and then was shaken on a benchtop orbital shaker for 2 hours. The samples were centrifuged (Thermo Multifuge 3S, Germany) for 10 minutes at ~ 1000 rpm. The liquid phase was removed and mixed in a centrifuge tube with 1 ml $CHCl_3$ and 1 ml of distilled water and thereafter vortexed for 10 seconds. After this the samples were centrifuged again for 10 minutes at 3000 rpm. The upper phase was taken with a glass pipette and discarded. The remaining phase contains all lipids and was evaporated using a vacuum centrifuge (miVac DUO Concentrator and pumping, GeneVac, UK).

Step 2: Lipid fractionation

The samples were redissolved in 2 ml $CHCl_3$. Silica gel columns (Isolute® SI 500 mg of 3 ml, Biotage, Sweden) were used to separate the lipid fractions. The neutral lipids such as ergosterol were washed with $CHCl_3$ and the glycolipids with C_3H_6O (Acetone). Afterwards the phospholipids were eluted with MeOH from the silica gel column and collected in centrifuge tubes. The samples were evaporated again with the vacuum centrifuge.

Step 3: Derivatisation modified by Gómez-Brandón et al. (2010)

The samples that contained now only phospholipids were redissolved in 200 µl of methyltertbutylether ($C_5H_{12}O$). 100 µl of this solution was removed to GC vials with spring-insert and mixed with 50 µl trimethylsulfonium (TMSH). After 30 minutes an internal standard (100 ppm nonadecanacid methyl ester 19:0.230 µL ml^{-1}) was added to each GC vial to quantify phospholipids.

Step 4: Measurement on the gas chromatograph

To measure the PLFA a gas chromatograph (HP 6890N Series, Agilent Technologies, China) equipped with an auto sampler (7683B Series injector, Agilent Technologies, USA) was used. The separation carried on a DB 23 capillary column (60 m, Ø 250 µm, 0.15 µm film thickness) and following detection with a flame ionization detector (FID). The injected volume from the samples was 1 µl in split less mode and Helium served as carrier gas throughout the run time (40.17 minutes).

Table 2 Oven parameters

Rate [°C min^{-1}]	Final temp [°C]	Final time [min]
30.00	150	1.00
1.00	150	0.00
4.00	230	15.00
0.0	(off)	(off)

The initial flow was set to 1.5 ml min^{-1}, the initial pressure was 196638.48 Pa and the average velocity 28 cm sec^{-1}. The front detector (FID) had a temperature of 300 °C, a hydrogen flow of 35 ml min^{-1}, an air flow of 300 ml min^{-1} and a combined flow of 12 ml min^{-1}.

Step 5: Evaluation of the chromatograms and classification of PLFA

The chromatograms were integrated with “Agilent ChemStation” (Agilent Technologies, Santa Clara, USA) and the PLFA were identified with an external standard (bacterial acid methylesters mix; BAME, SUPELCO, USA). The classification of the fatty acids to the current microorganisms was carried out according to Frostegård & Bååth (2014). The classification: gram+ i15:0, a15:0, i16:0, i17:0; gram- 14:0, 17:0, cy17:0(9/10), cy19:0(9/10); fungi 18:1(9)t, 18:1(9)c, 18:2(9/12)c; unspecific bacteria 2OH12:0, 15:0, 18:0.

2.4.5. Statistical Analyses

Statistical analyses were performed using Statgraphics Centurion XVI (Stat Point Technologies, Inc., USA) and the open source program R (version 3.2.0, 2015). The soil properties and nutrients, microbial parameters and extracellular enzyme activity graphs were created with Sigma Plot 11.0 and the PLFA graphs were created with Sigma Plot 12.0. Correlations were performed with n=12 (three treatments in four replicates). Differences between treatments were tested with one-way ANOVA. Significant differences were shown with the Tukey`s HSD test at a confidence interval of 95 %. For each location and treated or untreated layer, effects of lime and time were investigated using 2-way

ANOVA with treatment and sampling time as fixed factors. Further, in order to verify a difference between the treated and untreated layer, a t-test was performed. For correlation analysis, the open source program R (version 3.2.0, 2015) was used. The dataset was divided into two sets. One set represented the enzyme activities and the other one represented the environmental factors.

3. Results

3.1. **Effect of CaO and $CaCO_3$ on chemical and microbial parameters**

The pH value (Figure 3) increased immediately after the application of CaO (2 days) which was significant in the treated layer (0-7 cm). However, no effect was observed for the second sampling (30 days). Only the site Kemeten (KE) which originally had an acidic soil pH, showed an increase in pH value also after the application of $CaCO_3$. A 2-way ANOVA revealed that the factor “time x lime” was significant in the treated layer of the soils from the sites Strengberg (ST) and Pollham (PO), while the factor “lime” was significant for the site KE. In the untreated layer the factor “lime” was significant for all three sites.

The dissolved organic carbon (DOC; Figure 4) concentration increased immediately after the application (2 days) of CaO which was significant for the treated layer in all three sites. During the incubation period this effect declined: after 30 days differences were still significant, while for the DOC concentration after 86 days no differences to the control could be detected. Notably in the treated layer the interaction of the factors “lime x time” were highly significant at all three sites; however, in the untreated layer the factor “lime” was significant.

After the application of CaO there was an observed tendency of a declining C_{mic} (Figure 5) for the sampling sites ST and PO in the treated layer. After a time period of 86 days for the site PO there were no significant differences any more to the control. The C_{mic} concentration in the untreated layer was generally higher at the third sampling than of the first and second sampling in all three treatments. The interaction of the factors “lime x time” was only at the site ST in both layers same significant. Whereas at all three sites (except: PO, 0-7 cm) the factor “lime” was significant.

The N_{mic} concentration (Figure 6) at the site PO decreased immediately after the application of CaO and $CaCO_3$, which was significant in the treated layer. However, no effect was observed for the second (30 days) and third (86 days) sampling. At the site ST in the untreated layer the N_{mic} concentration was increased significantly by CaO after 30 days, but also this recovered after 86 days. The N_{mic} concentration at the sites PO and KE in both layer showed a significant increase after 30 days incubation time for all three treatments and remained constant also after 86 days (except: KE, CaO). In the treated layer of the sites PO and KE, the combined factor “time x lime” was significant, while the factor “lime” was significant at all three sites in the untreated layer.

The soil microbial biomass C:N ratio (SMBC:SMBN; Figure 7) increased immediately after the application of $CaCO_3$ (2 days) at the site PO which was significant in the treated layer, this value also changed a high significance between treated and untreated layer. The interaction of the factor “lime x time” was significant in the treated layer of the site PO, however, at all three sites (except: KE, 0-7 cm) the factor “lime” was highly significant.

The cellulase activity (Figure 8) in the treated layer decreased immediately after CaO application (2 days) at all three sites. Nevertheless, after 86 days of incubation no more differences in cellulase activity could be observed compared to the control. The combined factor “lime x time” was significant at the site ST (0-7 cm) and PO (both layers), while the factor “time” was significant in the treated layer at the site KE. In contrast the factor “lime” was most significant in the untreated layer of the sites ST and KE.

Chitinase activity (Figure 9) increased 30 days after CaO application at the site KE, but no effect was observed for the third sampling (86 days), while in the treated layer of ST the chitinase activity increased significantly 86 days after CaO application. Multifactorial ANOVA resulted in high significance of the combined factor “lime x time” for chitinase activity at the sites PO and KE in the treated layer. A “time” effect could be observed in the treated layer at the sites ST and PO, while the untreated layer only showed a “lime” effect.

The phosphatase activity (Figure 10) decreased immediately after the application (2 days) of CaO which was significant in the treated layer of ST, but during the incubation time the phosphatase activity leveled off at the original concentration of the control. In the acidic soil site of KE in both layers showed a significant increase for all treatments after 30 days. After 86 days no more effects on phosphatase activity was observed. The factor “lime x time” was significantly at the site ST in the treated layer, while the factor “lime” was significant in all three sites (except: PO, 7-14 cm) and for site KE the factor “time” was significant for phosphatase activity in the treated layer.

The protease activity (Figure 11) was reduced significantly after the application (2 days) of CaO in the treated layer of the sites ST and KE. But the site KE recovered already 30 days after application of CaO. Protease activity decreased significantly 30 days after $CaCO_3$ application. Protease activity significantly increased 30 days after $CaCO_3$ application in the treated layer of site KE, but no effect was observed for the third sampling (86 days). The untreated layer showed almost the same effects of liming on protease activity at all three sites. The combined factor “lime x time” was significant for the sites ST and KE in the treated layer, while the factor “time” and “lime” were highly significant at the site PO. In the untreated layer only the factor “lime” was highly significant at the sites ST and PO.

A short-term increasing effect (2 days) of CaO application on phenoloxidase activity (Figure 12) was observed in the treated layer at the site ST. However, during the incubation time the activity of phenoloxidase leveled off to the activity of the control. Phenoloxidase activity appeared to be significantly affected by the combined factor “lime x time” at all three sites in the treated layer. The factor ”lime” and “time” were significant in the untreated layer (except: KE, “time”).

The peroxidase activity (Figure 13) increased immediately after CaO application at the site ST in the treated layer, but no effect was observed for the second and third sampling. In contrast, the peroxidase activity decreased significantly after the application of $CaCO_3$ (30 days in both layers, at the sites ST and PO). However, after 86 days no significant differences were observed for PO. At the site KE a short-term decreasing effect (2 days) of $CaCO_3$ application on peroxidase activity was observed in the treated layer. A temporal trend for peroxidase activity could be seen with a decrease from the first to the second sampling and an increase from the second (30 days) to the third (86 days) sampling for all three treatments. While the combined factor “time x lime” was significantly determining changes in peroxidase activity in the treated layer of all sites, the factor ”lime” and “time” were significant in the untreated layer (except: KE, “time”).

In terms of microbial community structure (Figure 14-19) there was a decline in bacterial PLFAs (gram+, gram- and unspecific bacteria) immediately after the application of CaO (2 days). However, over the duration of the experiment the microbial community seemed to recover at the site PO, as 86 days after the application an increase in e.g. gram+ bacteria was observed compared to the control in the treated layer. A similar effect has been noticed for the fungal PLFAs (except: ST).

For the ammonium (NH_4^+; Figure 20) concentration a “time” trend was observed for the sites ST and PO in the treated layer. While for the soil of the site KE the factor “lime” was significant and the liming also seemed to have an effect on the ammonium concentration in the untreated layer.

A short term effect (30 days) of CaO application on nitrate concentration (NO_3^-; Figure 21) was observed in the treated layer. At the sites PO and KE the nitrate concentration was increased significantly after 30 days compared to the control. However, after a time period of 86 days there was no significant difference to the control. The combined factor “time x lime” was significant for the treated layer of the sites PO and KE, whereas the factor “lime” was significant for ST (0-7 cm).

The concentration of dissolved nitrogen (DN; Figure 22) increased significantly immediately after the application (2 days) of CaO in the treated layer of the sites PO and KE. Nevertheless, his effect was not obvious anymore after 86 days of incubation. Noticeably the interaction of the factors “lime x time” was highly significant in the treated layer at the sites PO and KE , however in the untreated layer only the factor “lime” was significant at all three sites.

3.2. Effect of CaO and $CaCO_3$ in the treated and untreated layer

The application of CaO resulted in a pronounced difference in pH (Figure 3) between the treated and untreated layer at the first and second sampling at all three sites. However, $CaCO_3$ application only significantly affected the originally acidic soil from the site KE, especially in the initial and intermediate samplings. Almost the same results were observed for DOC concentration (Figure 4), still the CaO application caused significantly higher DOC concentrations in the treated layer compared to the untreated at all sites, for the first and second sampling. This difference was not as strong for the treatment with $CaCO_3$. The NO_3^- (Figure 21) concentration were significantly higher in treated compared to untreated layers at all three treatments for all sites, especially at the first and second sampling. Surprisingly the ammonium concentration showed no differences. In the initial and intermediate sampling the DN concentration (Figure 22) was significantly higher in the treated layer after CaO- and $CaCO_3$ application than in the untreated layer at all sites (except: KE, $CaCO_3$). A significant difference in C_{mic} concentration (Figure 5) between treated and untreated layer after CaO and $CaCO_3$ application at the site ST (30 days) and at the site PO (2 days) was observed, with higher concentrations in the untreated layer. The N_{mic} concentration (Figure 6) showed the same effect but only at the site PO. However, the soil microbial biomass C:N ratio (Figure 7) showed a significant difference between treated and untreated layer immediately after $CaCO_3$ application at the site PO.

The cellulase activity (Figure 8) showed a significant difference between treated and untreated layer for the sites ST and PO, especially after the application of CaO and $CaCO_3$, the phosphatase (Figure 10) and protease activity (Figure 11) only 30 days after CaO application.

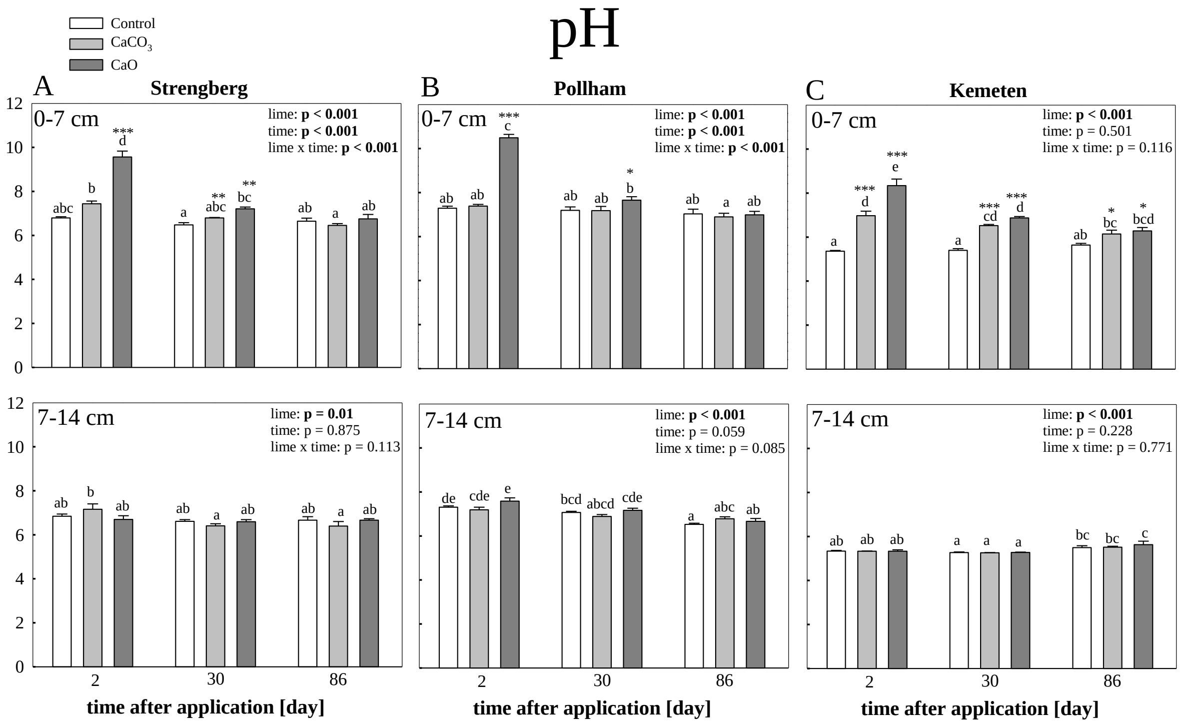

Figure 3 pH ($CaCl_3$) for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

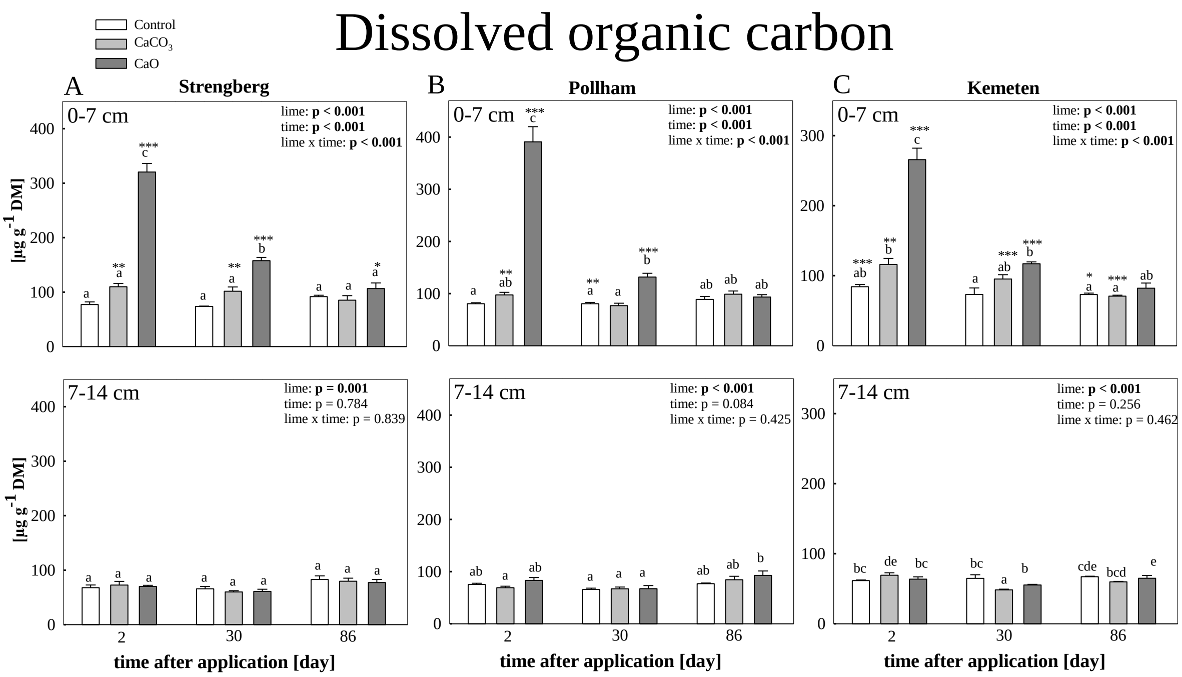

Figure 4 DOC for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

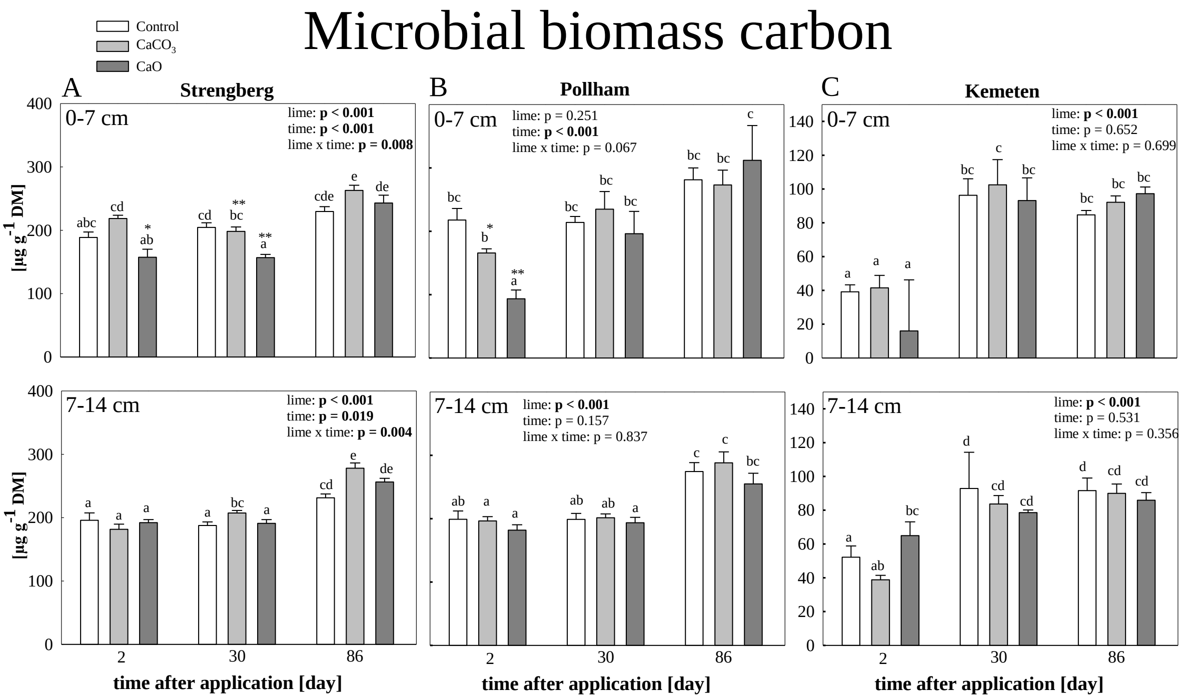

Figure 5 Microbial biomass carbon for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

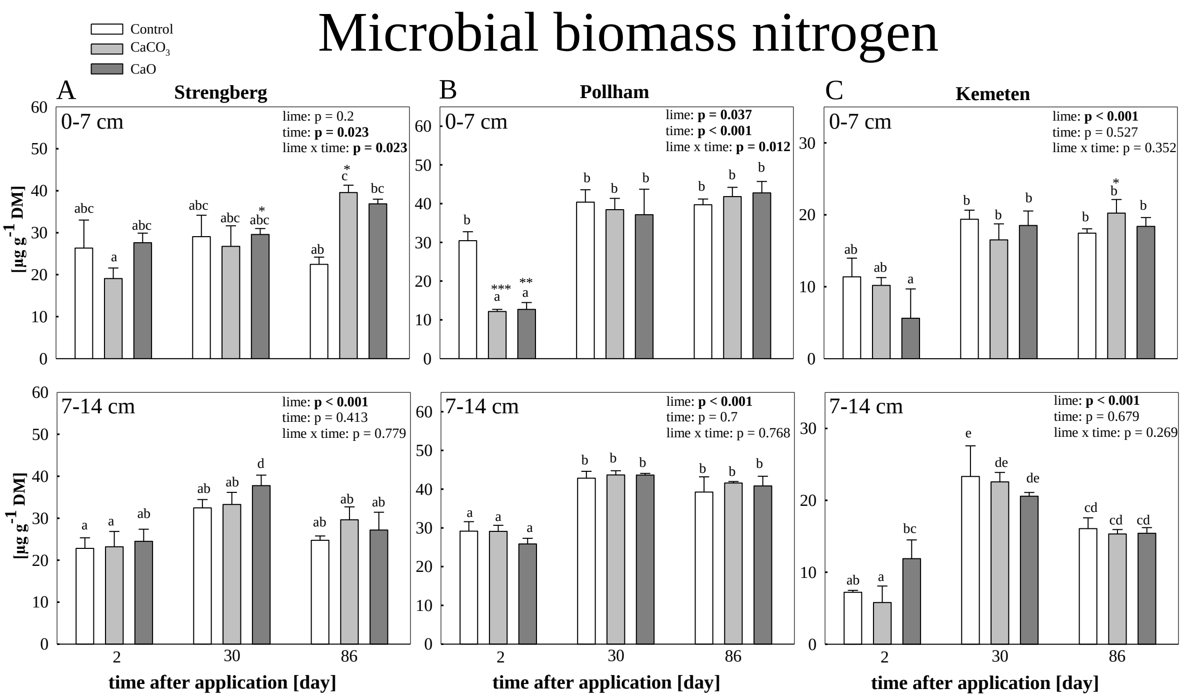

Figure 6 Microbial biomass nitrogen for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction

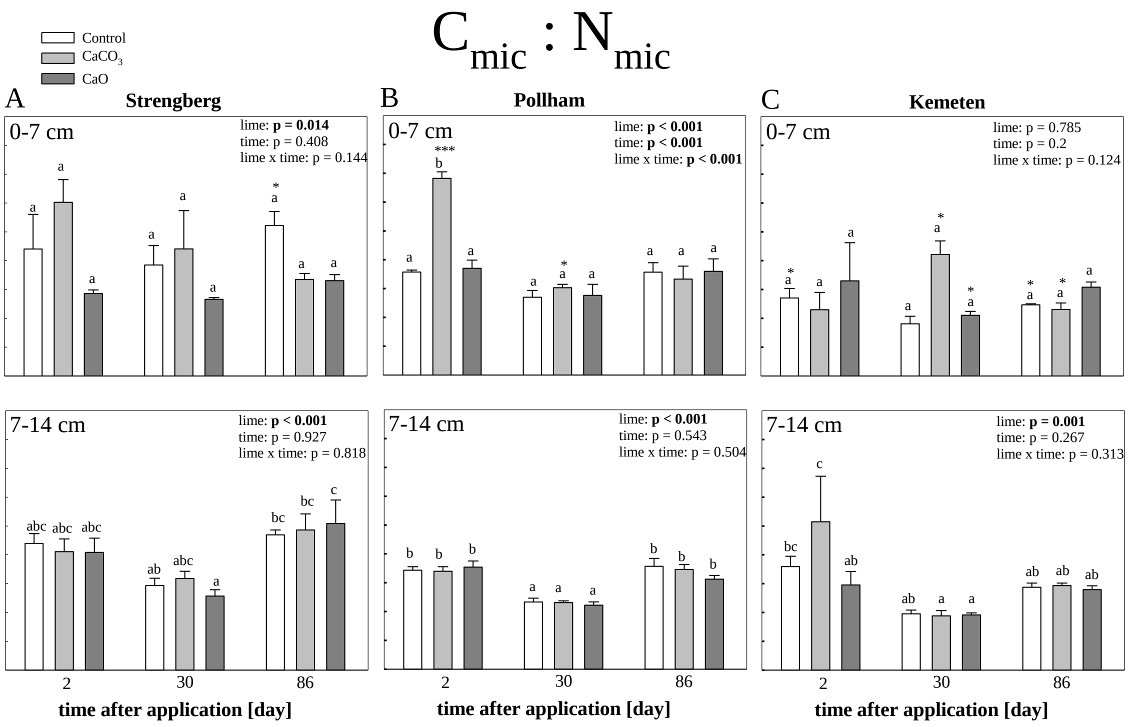

Figure 7 C_{mic}:N_{mic} for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

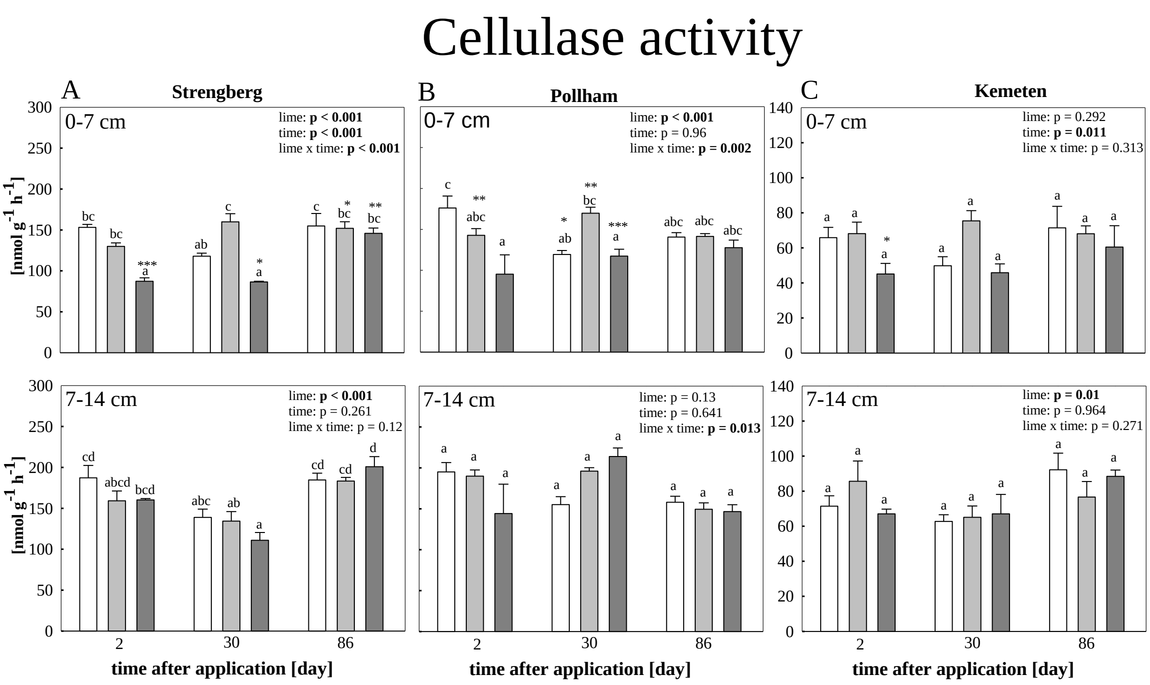

Figure 8 Cellulase activity for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

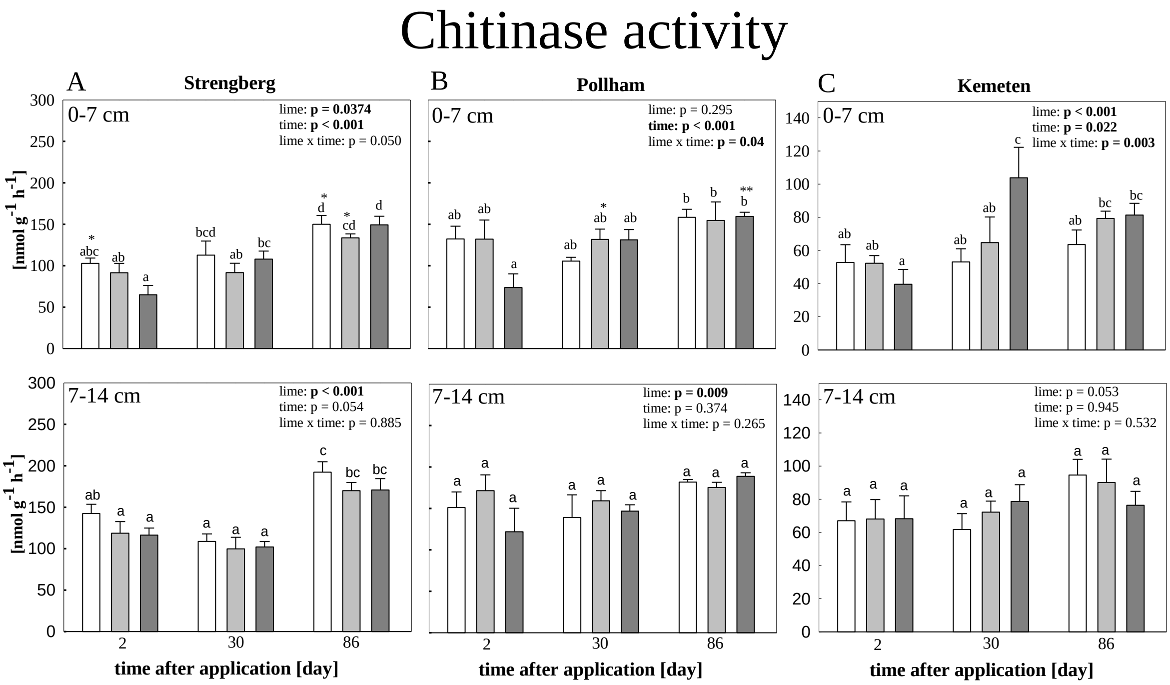

Figure 9 Chitinase activity for the sites Strengberg “A”, Pollham “B” and Kemeten “C”; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for “lime” (form of lime), “time” (time after application) and “lime x time” are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

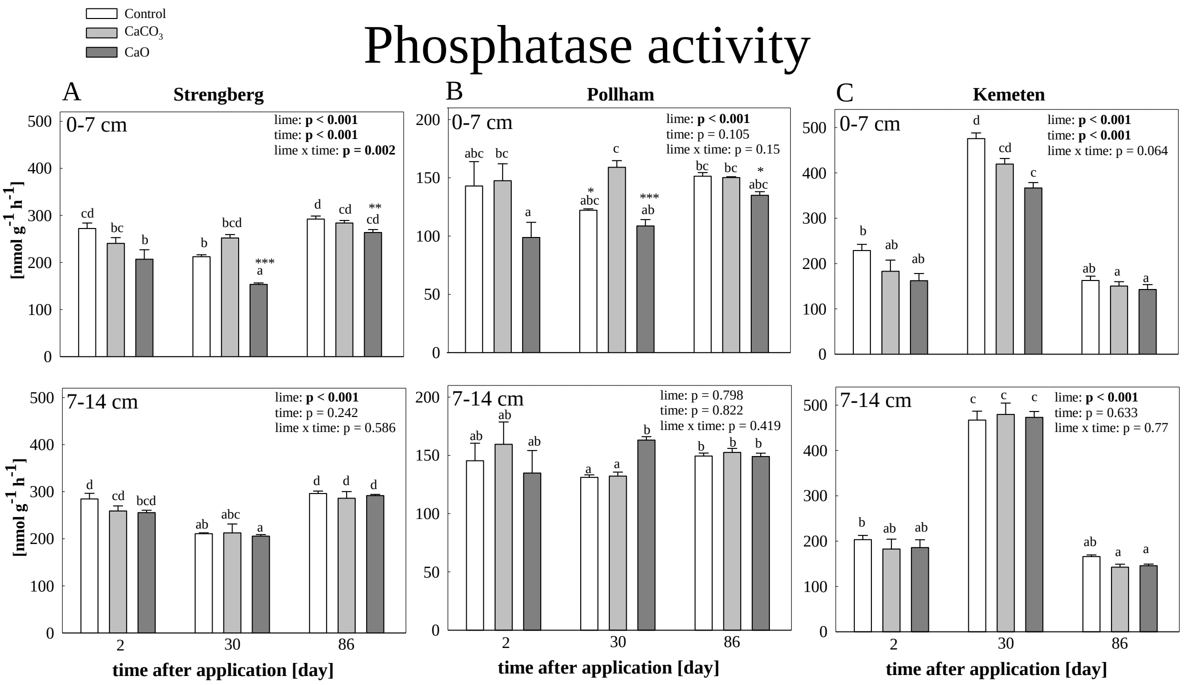

Figure 10 Phosphatase activity for the sites Strengberg “A”, Pollham “B” and Kemeten “C”; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for “lime” (form of lime), “time” (time after application) and “lime x time” are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

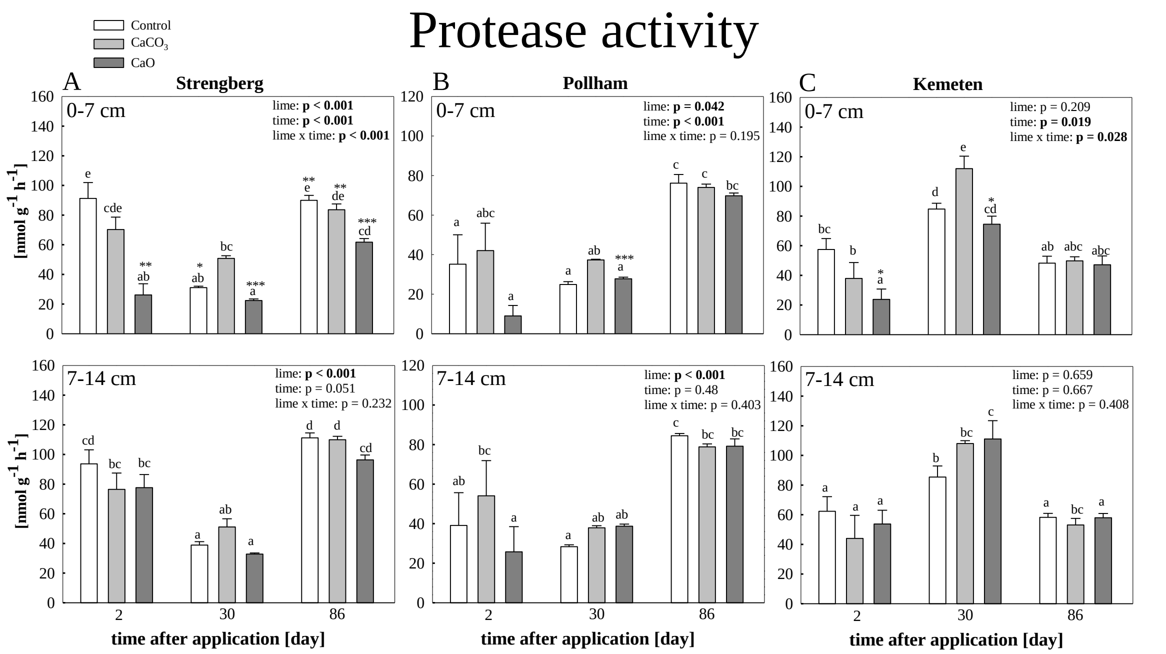

Figure 11 Protease activity for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

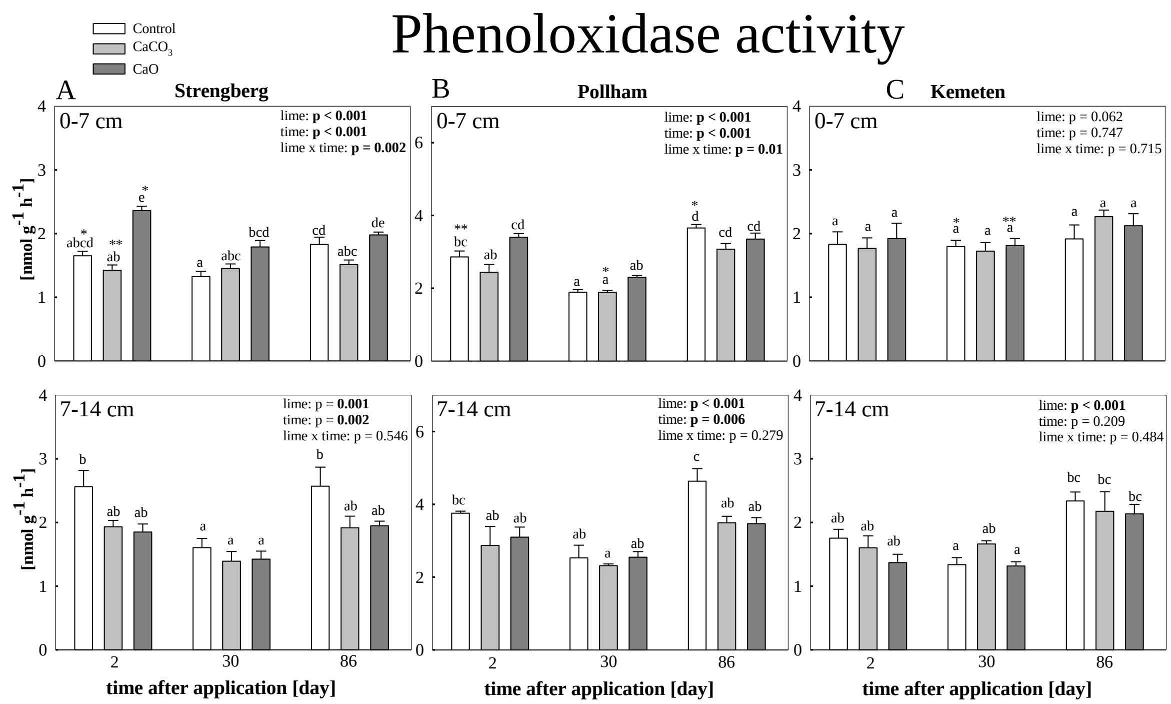

Figure 12 Phenoloxidase activity for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

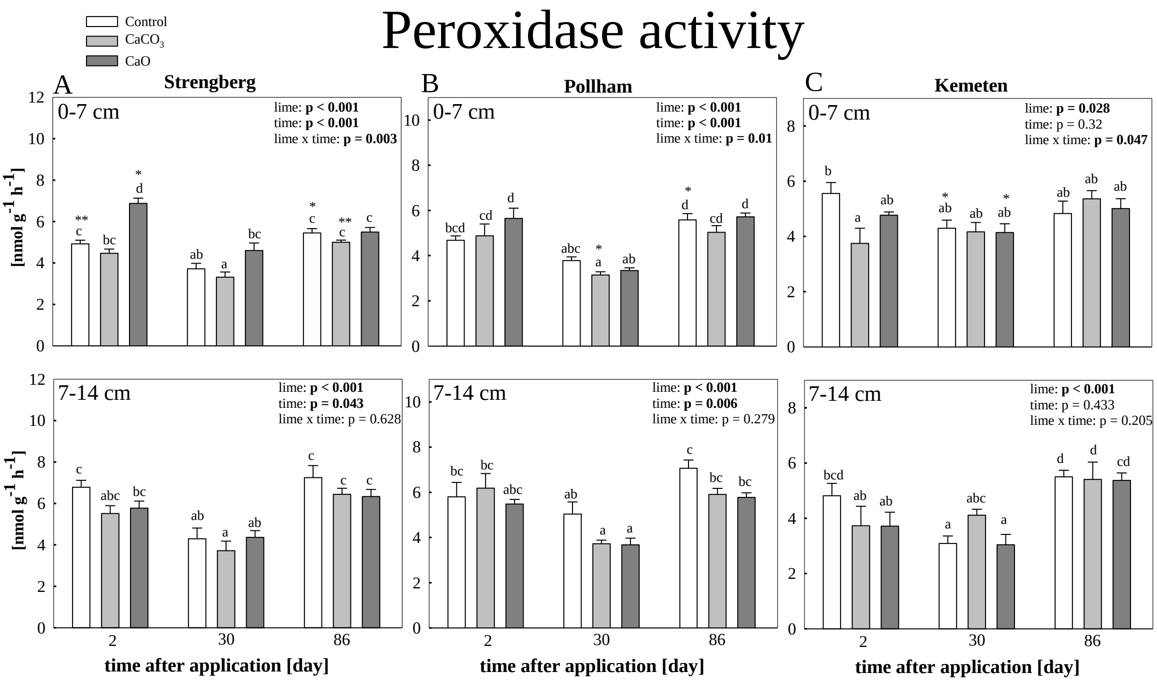

Figure 13 Peroxidase activity for the sites Strengberg “A”, Pollham “B” and Kemeten “C”; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for “lime” (form of lime), “time” (time after application) and “lime x time” are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

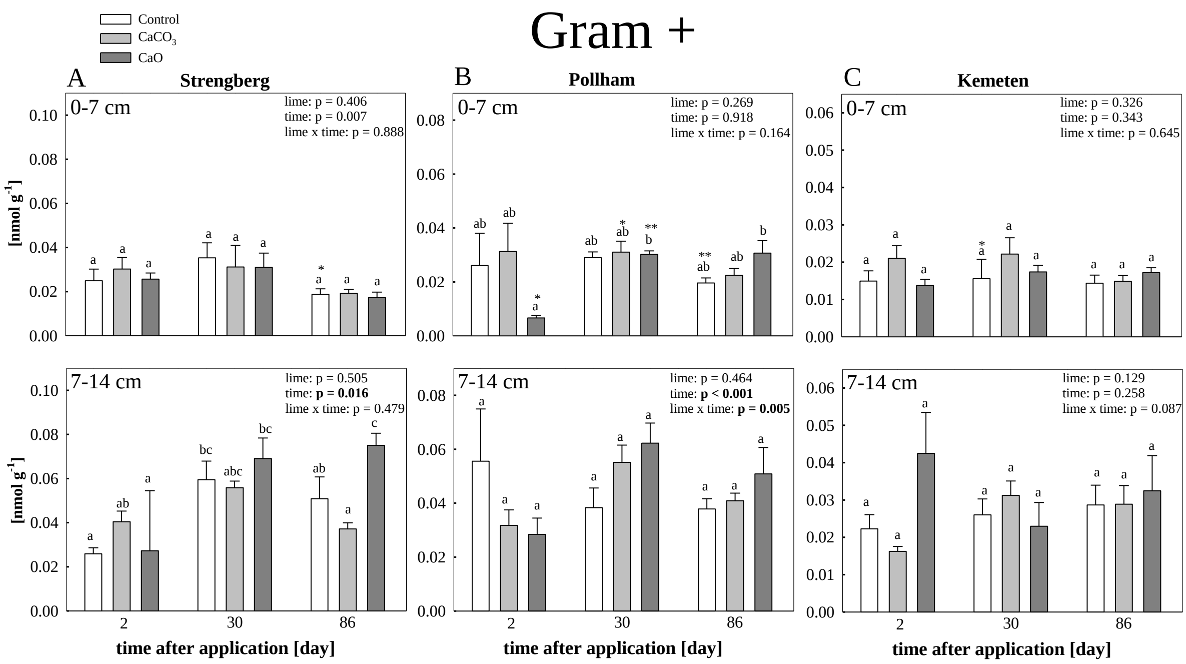

Figure 14 Gram+ bacteria for the sites Strengberg “A”, Pollham “B” and Kemeten “C”; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for “lime” (form of lime), “time” (time after application) and “lime x time” are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

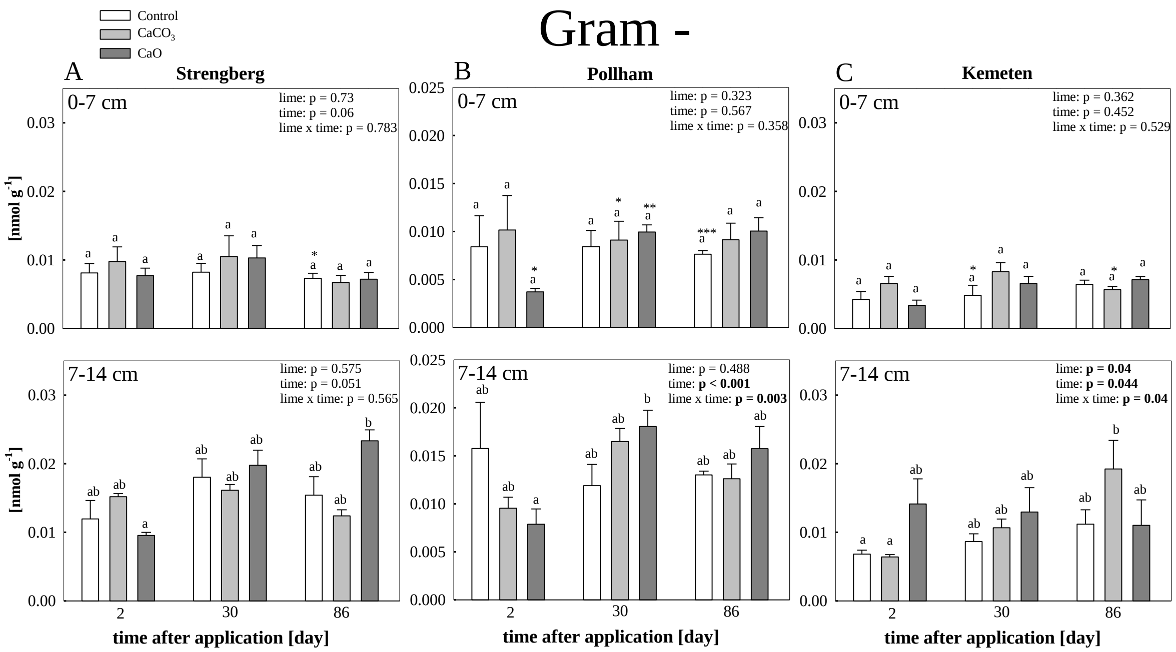

Figure 15 Gram- bacteria for the sites Strengberg “A”, Pollham “B” and Kemeten “C”; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for “lime” (form of lime), “time” (time after application) and “lime x time” are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

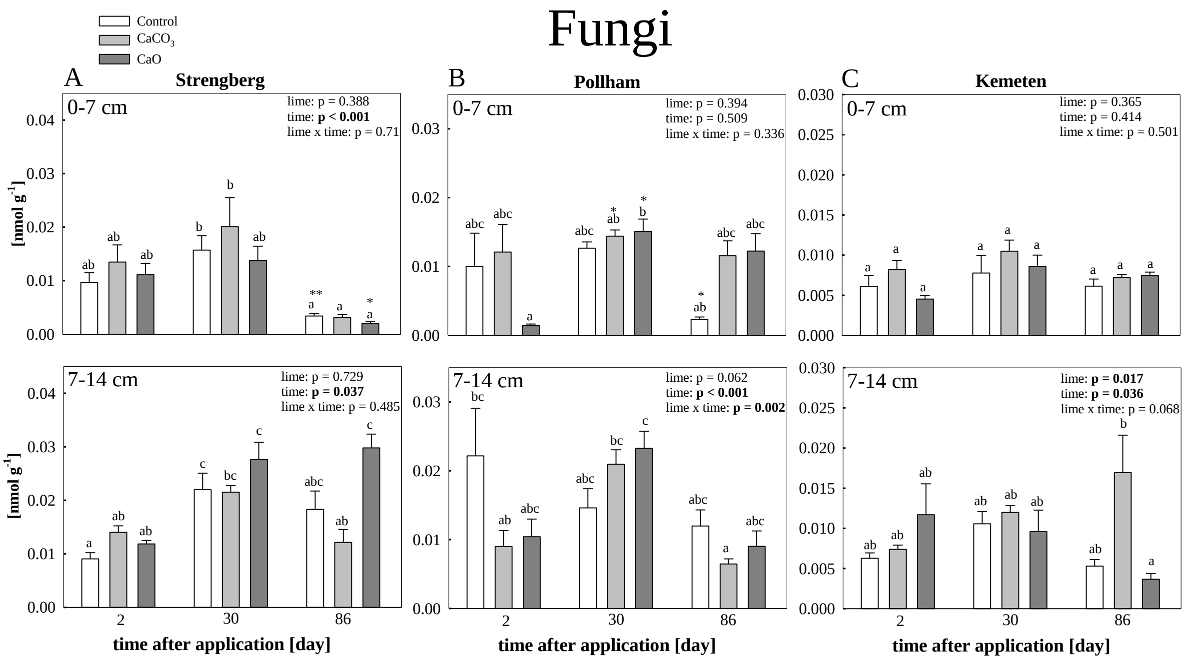

Figure 16 Fungi for the sites Strengberg “A”, Pollham “B” and Kemeten “C”; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for “lime” (form of lime), “time” (time after application) and “lime x time” are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction

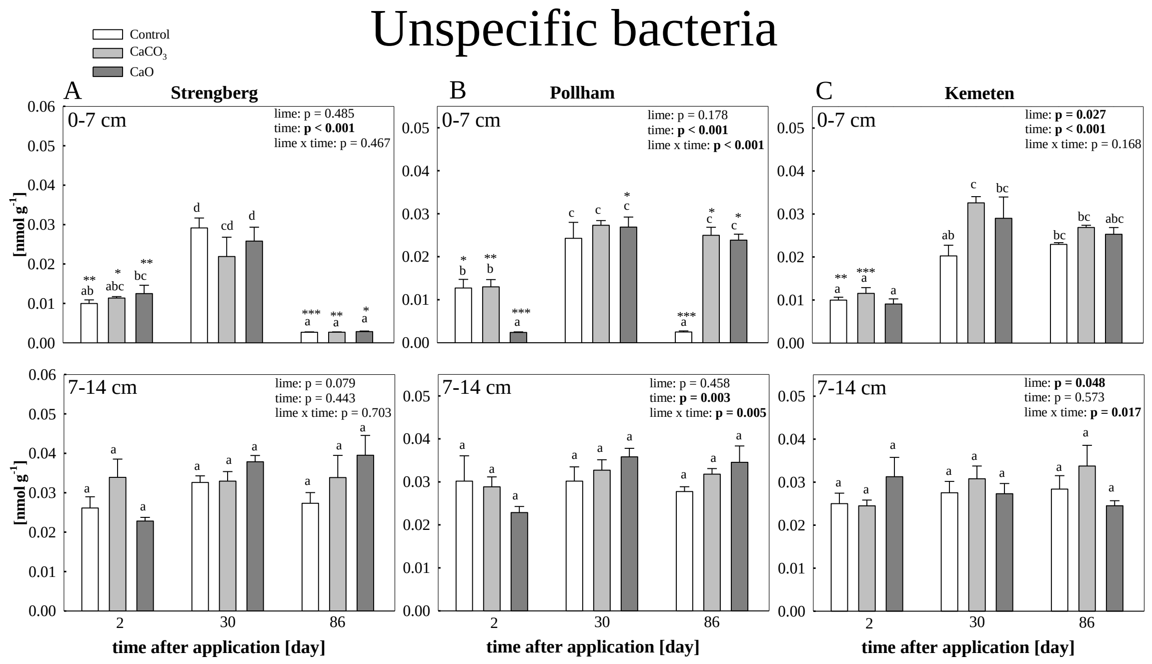

Figure 17 Unspecific bacteria for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

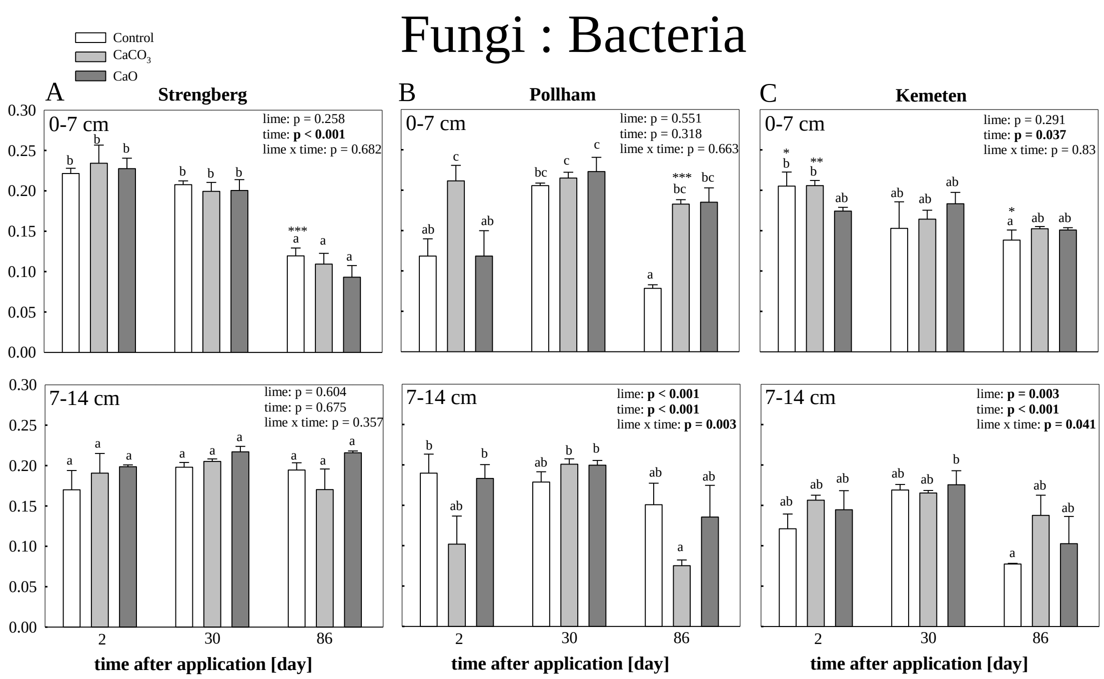

Figure 18 Fungi : Bacteria for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

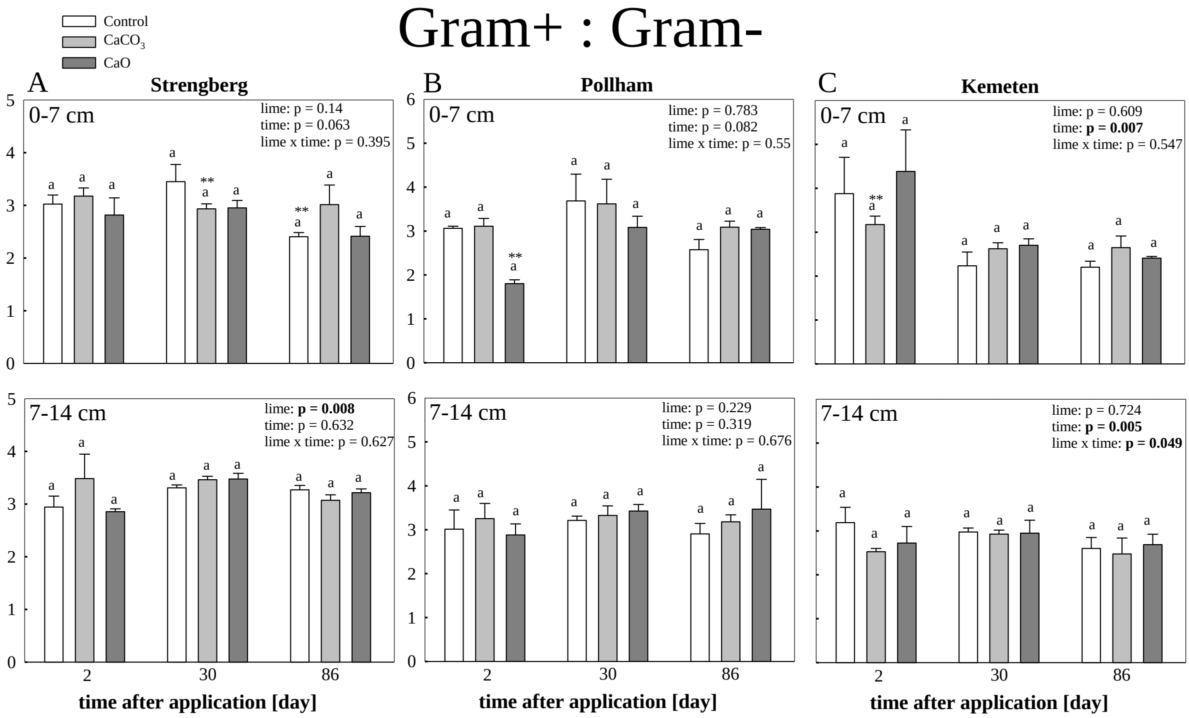

Figure 19 Gram+ : Gram- for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

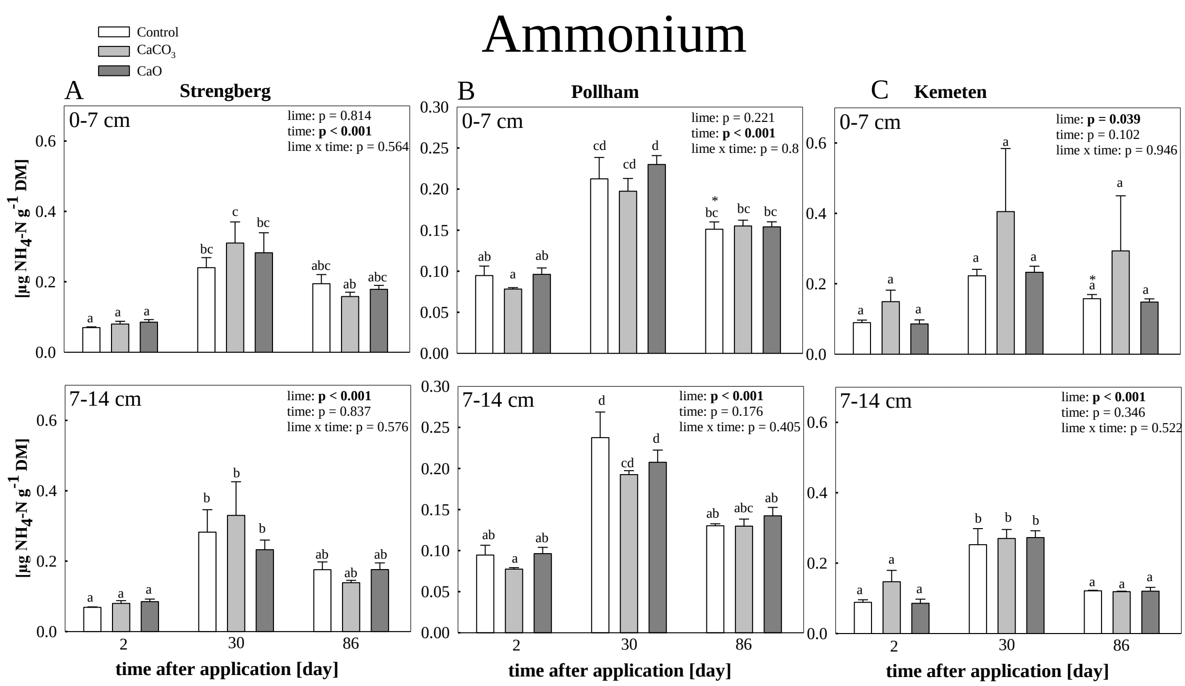

Figure 20 Ammonium for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

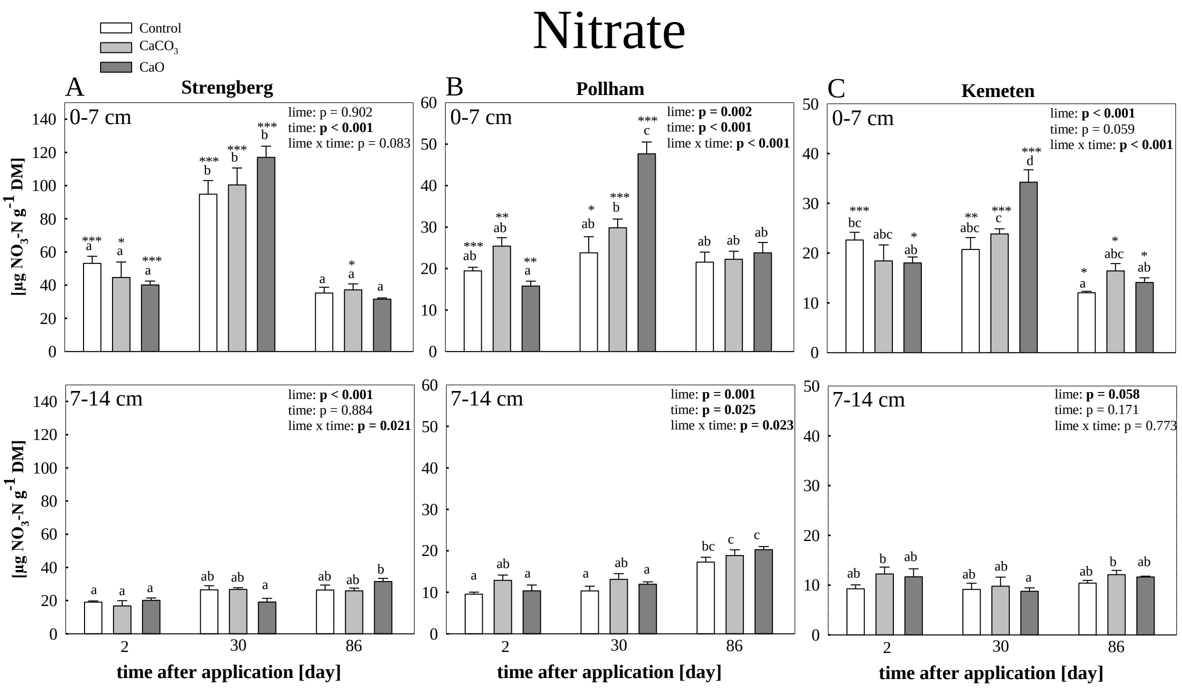

Figure 21 Nitrate for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

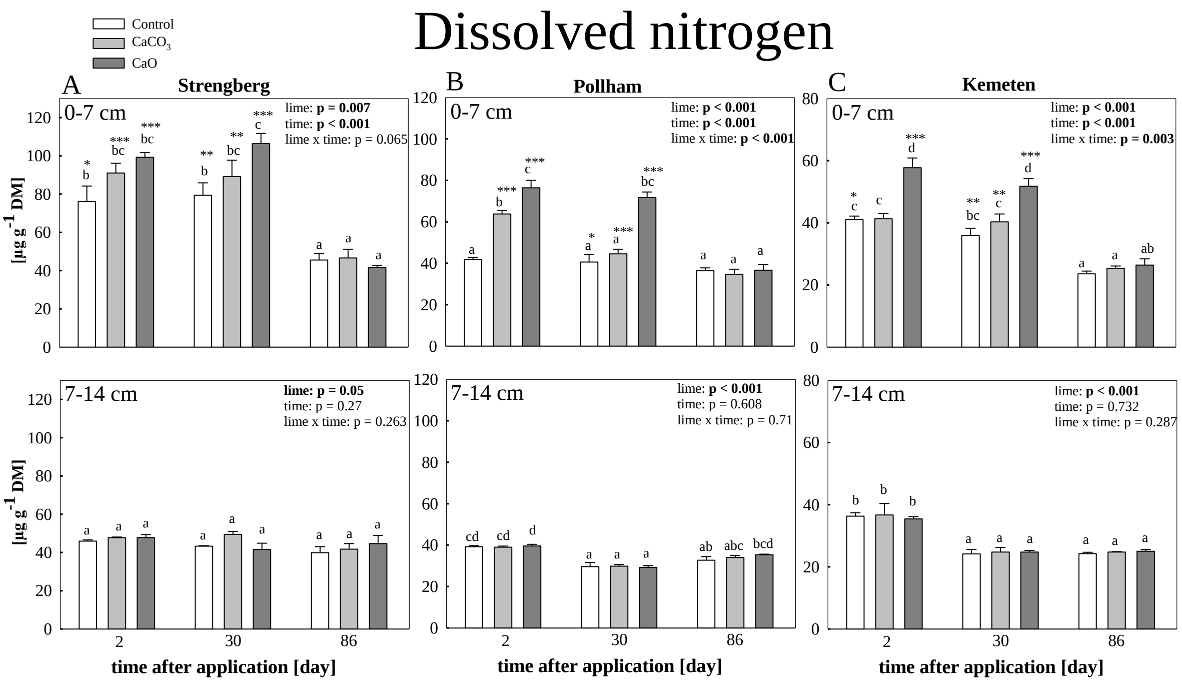

Figure 22 Dissolved nitrogen for the sites Strengberg "A", Pollham "B" and Kemeten "C"; 0-7 describes the treated layer (application of CaO and $CaCO_3$); 7-14 cm describes the untreated layer. Letters indicate differences in multiple comparison of mean by Tukey´s HSD ($p < 0.05$ with a confidence level of 95 %); stars show significant differences between the two soil layers (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); the p values for "lime" (form of lime), "time" (time after application) and "lime x time" are from a 2-way ANOVA (confidence level of 95 %) and indicate significance of the individual factors or their interaction.

4. Discussion

4.1. Short term liming effects on chemical and microbial parameters

As described in various studies, it is obvious that the application of $CaCO_3$ can significantly increase soil pH. Acosta-Martínez et al. (2000) described a field experiment (17,920 kg ha^{-1} $CaCO_3$) where the soil pH was increased after 7 years from 4.9 to 6.9. Caires et al. (2011) reported a significant increase in pH after the incorporation of lime (4.5 t ha^{-1}: 244 g kg^{-1} Ca, 140 g kg^{-1} Mg and 89 % effective calcium carbonate equivalent) in a tilled field after 8 years. Fuentes et al. (2006) discussed increases in soil pH of 2.8 units, 56 days after 17,600 $CaCO_3$ kg ha^{-1} was incorporated in a Palouse silt loam (pH 4.9-5.4; annual fertilization for 29 years: 120 kg N ha^{-1} for winter wheat and 80 kg N ha^{-1} for spring wheat). Bertrand et al. (2007) observed almost the same results as in our study. They reported that in acidic soils the pH increased during the first 14 days of incubation (sandy loam; application rate: 18,000 kg ha^{-1} in 1985). In our study, only the site KE (Figure 3 C), which originally had an acidic soil pH (5.3), showed an increase in pH 2 days after the application of $CaCO_3$ with a slight decrease throughout the experiment; however, the low initial value was not reached after 3 months. We suggest that lower application rates of $CaCO_3$ in the present short-term experiment could explain that pH significantly increased only at the site KE with originally acidic pH compared to other studies. On the contrary, after the application of CaO, the pH immediately (2 days) increased at all three sites (Figure 3), but decreased at the third sampling to its initial value (control). These results indicate that CaO reacts much faster than $CaCO_3$ because of its higher solubility in the soil. The high solubility may be advantageous for structure stabilization, but the rapid change in pH may negatively affect soil microbes. A possible explanation, why the pH increased only temporarily after lime addition, could be: (i) That addition of Ca^{2+} ions led to the release of protons from the soil humus-mineral-complex, which decreased the pH again. This reaction is slow and therefore was only visible at the second and third sampling. (ii) Leaching of OH^- ions through time.

Microbial activities could be affected by liming directly or through changes in their soil micro-environment (Alexander, 1977). Factors which affect environment are plant cover, animal activity, wetness, fertilizer application, pH (Vos *et al.*, 2013) and aggregate stability (Buttery *et al.*, 1998). Microbes, especially bacteria which are most prominent in agricultural soil (Six *et al.*, 2006), prefer a neutral pH in their living conditions, while fungi also tolerate more acidic conditions (Blagodatskaya and Anderson, 1998). Therefore a higher microbial turnover may increase the production of DOC (Andersson *et al.*, 2000). The effects of liming materials have been mainly studied on the field scale, with large application rates on the long term. However, also pot experiments have been used. For example, Filep (2003) applied 3 g calcite and 2.76 g dolomite per pot, respectively, and found a significant increase of DOC due to liming. In the present experiment, the linear relationships among all treatments and sites did not show any significant correlations between DOC and pH. However, an apparent trend in the canonical correspondence analyses (CCAs; conducted for each individual site; Figure 23) between pH and DOC was observed. Interestingly, the application of $CaCO_3$ caused no effects on DOC, but DOC increased immediately after the application of CaO at all three sites (Figure 4), with a similar trend as pH. Long term application of liming has been shown to increase microbial biomass (MB = C_{mic} and N_{mic}; Alexander, 1977; Adams and Adams, 1983; Ekenler and Tabatabai, 2003). Bezdicek et al. (2003) observed increased C_{mic} one year after application $CaCO_3$ of 2,680 kg ha^{-1}. A potential reason for the beneficial effect of "long-term" liming on the microbial biomass has been ascribed to the changes in C-quality available to microbes that changes with soil pH (Ekenler and Tabatabai, 2003). Our results showed a significant increase of C_{mic} after 86 days of $CaCO_3$ application at the site ST (Figure 5 A) and 30 days after application at the site KE, while for the site KE also the control treatment increased (Figure 5 C). However, the site PO (Figure 5 B) showed a decrease of C_{mic} 2 days after the application of $CaCO_3$ and CaO, but the effect was temporary. In general, the concentration of C_{mic} declined after the application of CaO compared to $CaCO_3$ and rose towards the end of the experiment. This is likely to be attributable to the extreme rise in pH (Figure 3) at the beginning of our experiment, with a resilience of the microbial community when the pH turns back into neutral ranges. A decrease in N_{mic} (Figure 6) could be observed 2 days after the application of $CaCO_3$ and CaO, but this was only a short term effect. It is possible that the effect of liming on changes in MB is not always predictable (Ivarson, 1977), while over time changes in microbial succession may occur. The pH changes do not only affect microbial community composition and their activity. To this end we conducted extracellular enzyme activity (EEA) measurements. Many factors are known to influence soil enzyme activities, including soil organic matter, water content, soil texture and structure, as well as soil temperature and pH (Awad *et al.*, 2012). Water content was kept constant for all pots and treatments throughout the pot experiment but the pH changed temporarily after the application of CaO (Figure 3). The organic matter did not change significantly after the application of liming materials compared to the control (data not shown) and the soil temperature was assumed to be the same among the different treatments. Results of correlation analysis (Table 3) indicate that most hydrolytic EEA and MB were significantly interacting in terms of positive correlations at all sites (among all treatments). The results from our pot experiment are consistent with most field studies that also observed correlations between MB and EEA, which are involved in N, C and P cycling (Klose and Tabatabai, 2000; Bezdicek *et al.*, 2003; Bowles *et al.*, 2014).

Soil pH correlated positively with hydrolytic enzymes, like β-Glucosidase, L-Asparaginase, L-Glutaminase and acid Phosphatase after application of 17,920 kg ha^{-1} $CaCO_3$ in a long-term field experiment (Acosta-Martínez and Tabatabai, 2000). There is a general agreement that increasing pH values (through application of $CaCO_3$) of intensively managed field sites could positively influence the soil microbiology (Andersson *et al.*, 2000). However, in our short term pot experiment the application of $CaCO_3$ did not result in increased hydrolytic EEA, and the application of CaO even had an opposite effect - hydrolytic EEA (Figure 8-11) decreased immediately after the application, but again this was a short-term effect and the EEA recovered at the last sampling time. The stability of hydrolytic EEA seemed to be strongly dependent on soil pH. We even found negative effects of liming on the short-term, which was possiblely due to the high temporal resolution of measurements after application.

Table 3 Single linear regression (SLR) of microbial biomass and extracellular enzyme activities for the sites Strengberg "ST", Pollham "PO" and Hartberg "HA". The values in italic indicate significance (confidence interval of 95 %).

	ST				PO				HA			
	C_{mic}		N_{mic}		C_{mic}		N_{mic}		C_{mic}		N_{mic}	
	R^2	**p**	**R^2**	**p**	**R^2**	**p**	**R^2**	**p**	**R^2**	**p**	**R^2**	**p**
Cellulase	*0.622*	*<0.001*	0.052	0.763	0.253	0.136	0.178	0.3	0.096	0.579	0.056	0.745
Chitinase	*0.657*	*<0.001*	0.307	0.068	*0.494*	*0.002*	*0.387*	*0.02*	*0.504*	*0.002*	*0.496*	*0.002*
Phosphatase	*0.699*	*<0.001*	0.109	0.528	*0.432*	*0.009*	0.238	0.162	*0.368*	*0.027*	0.284	0.094
Protease	*0.648*	*<0.001*	0.092	0.595	*0.611*	*<0.001*	*0.413*	*0.012*	*0.577*	*<0.001*	*0.427*	*0.01*
Phenoloxidase	-0.310	0.065	0.087	0.615	0.105	0.541	-0.07	0.696	-0.108	0.532	0.073	0.6716
Peroxidase	-0.128	0.458	0.064	0.71	0.056	0.746	-0.195	0.255	-0.069	0.689	0.026	0.882

To our knowledge, this is the first study linking liming with oxidative enzyme activities. We found an immediate (2 days) increase of peroxidase and phenoloxidase EEA (Figure 12-13) after CaO application at the site ST, but no effect was observed for the second and third sampling. Generally in acidic soils fungi are more resistant and remain active over a wide range of pH (Lauber *et al.*, 2009; Rousk *et al.*, 2010). We propose that the activities decreased with pH over time and depend on sampling sites. This is in accordance to what has been observed in another study, i.e.: (i) Generally oxidative enzymes are supposed to increase with soil pH (Sinsabaugh, 2010); (ii) In addition phenoloxidase and peroxidase activity was mentioned to be less stable than hydrolytic enzymes, especially when they are associated with organic particles (Sinsabaugh, 2010).

In our study, the fast increase of pH through CaO application showed a short term reduction in hydrolytic EEA, which indicates a reduction of CNP cycling. However, the decomposition of soil organic matter may be increased trough the increase of oxidative EEA. The reduction in soil organic matter could reduce soil C sequestration. We conclude that the changes in EEAs through the application of liming materials indicated a stress reaction.

Few studies examined the effect of liming material on N-mineralization and nitrification. A rapid oxidation of NH_4^+ to NO_3^- leads to lower NH_4^+ concentrations. In the present study the concentration of NH_4^+ and NO_3^- could not only be attributed to the increased pH after liming, but may also have been affected by increased aggregate stability (Bauer, 2015), which leads to better aeration. For the site ST and PO, there was a trend of increased concentration of NH_4^+ (Figure 20 A, B) at the second sampling and a slightly decrease at the end of the experiment at the sites ST and PO for all three treatments. The former might be explained by more favorable conditions for mineralization at the second sampling, which also changed over time with microbial succession. However, the NO_3^- concentration (Figure 21) increased significantly after the application of CaO at the second sampling. This could be through the improved aggregate stability which might lead to a better aeration of the soil (Bauer, 2015). However, increased NO_3^- concentration has also been reported in a laboratory incubation experiment after an application of 4,400 kg ha^{-1} $CaCO_3$; probably the conditions became more favorable over time for nitrification. The authors of that study suggest that the application of $CaCO_3$ improved the stable pool of organic matter with some fraction was also available for mineralization (Fuentes *et al.*, 2006). In our study, the NO_3^- increase with liming could be attributed not only to improved aggregate stability after CaO application, but also that nitrifiers have their optimal growth conditions at pH values > 5.5. However, only one soil in this study was acidic (Figure 3 C), therefore the relationship between NO_3^- and pH needs to be carefully interpreted. Contrary to our results, Alexander (1977) reported no effects on soil NO_3^- and NH_4^+ concentrations after liming over 4 years.

Former studies described pH value as a predictive factor for microbial community (Sinsabaugh, 2010). Specifically, increased pH value due to liming caused a shift towards more gram- bacteria and reduced gram+ (Frostegård *et al.*, 1993). Surprisingly, the application of liming material showed only few effects on microbial community structure measured by PLFAs in the present study (Figure 14-19).

To our knowledge, no studies examined the effect of CaO on soil microbial community and activity. In addition, other liming studies applied $CaCO_3$ in much higher rates compared to our study. This could probably be a reason why we could only see few effects after the application of $CaCO_3$. However, the applied rate at the present experiment was selected according to the Austrian guidelines for agricultural soil fertilization and should be of practical relevance ("Richtlinien für sachgerechte Düngung"; Baumgarten, 2006). Our pot experiment enabled controlled conditions but excluded the impact of plants. Yet, we can confirm our hypothesis, that due to the high solubility and the strong increase of pH the application of CaO caused a short term effect on all microbial parameters. However, $CaCO_3$ is less rapidly soluble and the pH effect is depressed, therefore the effect on microbial parameters is lower and later.

4.2. Differences between treated and untreated layers

To study a potential depth proportion of liming effects, the liming material were applied only in the upper 7 cm, but also the underlying layer was analyzed. To account for the disturbance of the application procedure, also the control was manipulated. Immediately application of the liming materials there was only small effect in the deeper untreated layer. However, we assumed to see differences after some time as the liming material may influence the untreated layer after some percolation has occurred. The application of liming materials did not yield any differences for pH (Figure 3), DOC (Figure 4), NO_3^- (Figure 21) and DN (Figure 22) after the application. The site KE was an exception and showed an increase immediately after the application of CaO, which changed over time with microbial succession.

The hydrolytic EEA (Figure 9-11) in the untreated layer behaved the same as in the treated layer. However, the increased effect for oxidative EEA (Figure 12-13) at the first sampling time after the application of CaO in the treated layer could not be seen in the untreated layer. Apparently the effect of the liming material was too weak or the application rate was too low. We propose that the EEA can not only be linked to the pH, as described by Awad et al. (2012). The above results support our hypothesis, that the effect of CaO and $CaCO_3$ is higher in the upper layer (treated) than in the lower layer (untreated).

In contrast to our experiment, Caires et al.(2011) increased the pH to a depth of 60 cm 8 years after application of 4,500 kg ha^{-1} limestone (244 g kg^{-1}Ca, 140 g kg^{-1} Mg and 89 % effective calcium carbonate). We propose that the untreated layer was affected less by the liming materials because of our low application rate in this short-time experiment. This is in line with the statement of Caires et al. (2011) that the movement to deeper soil layers depends on soil type, application rate, frequency of application, timing of application and annual precipitation (> 1000 mm).

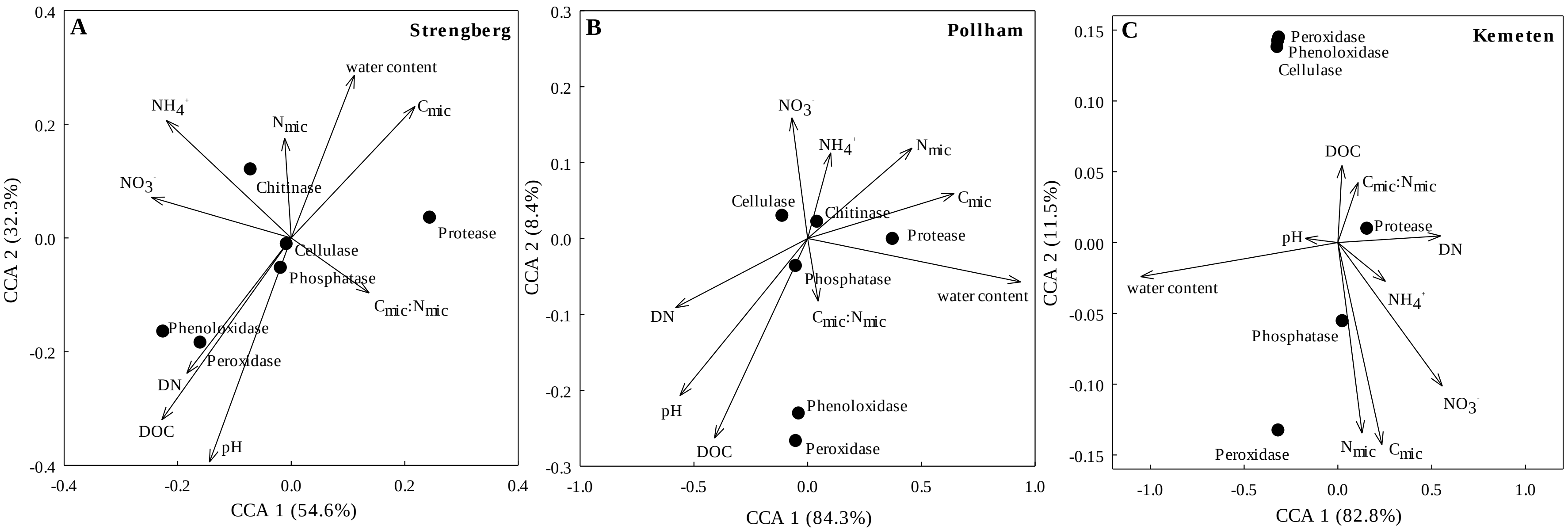

Figure 23 Canonical correspondence analysis (CCA) for the sites Strengberg "A", Pollham "B" and Kemeten "C" for the untreated layer. CCA shows correlation between extracellular enzyme activities (black dots) and soil chemical and microbial parameters (arrows). Dots and arrows that are close together are positively correlated, and those that are opposite to each other are negatively correlated. The contribution of constrained variability to total variability was 57 % for "A", 65 % for "B" and 79 % for "C" of which CCA 1 accounted for 54.6 %, 84.3 % and 82.8 % and CCA 2 for 32.3 %, 8.4 % and 11.5 %, respectively.

5. Summary and Conclusion

- The soil pH increased strongly immediately after the application of CaO, while the application of $CaCO_3$ showed only a slight effect in an acidic soil. Over three months the ph-value returned to control levels.
- The effects of CaO application were only short term for all parameters, probably because the pH value stabilized again. The application of $CaCO_3$ showed almost no effects. In contrast to other studies we applied much less $CaCO_3$ and only for a short term study. Perhaps an effect would have appeared later, due to the delayed solubility of $CaCO_{3.}$
- The reaction of microorganisms to liming material was very soil specific.
- Application of CaO led to a short-term decrease of microbial biomass and hydrolytic EEA, while oxidative EEA increased.
- In the underlying untreated layer, the effects were weak.

We conclude that the application of quicklime had only a short-term impact on most microbial parameters.

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7. Appendix

Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Treated layer [0-7 cm]	Repli-cate	pH	water content [% w/w]	cellulase activity [nmol $g^{-1}h^{-1}$]	exochitinase activity [nmol $g^{-1}h^{-1}$]	Phophatase activity [nmol $g^{-1}h^{-1}$]	Protease activity [nmol $g^{-1}h^{-1}$]	Phenol-oxidase activity [nmol $g^{-1}h^{-1}$]	Per-oxidase activity [nmol $g^{-1}h^{-1}$]	Am-monium [µg g^{-1} DM]	Nitrate [µg g^{-1} DM]	Dis-solved organic carbon [µg g^{-1} DM]	dissolved nitrogen [µg g^{-1} DM]	Micro-bial carbon [µg g^{-1} DM]	Micro-bial nitrogen [µg g^{-1} DM]	Dis-solved organic nitrogen [µg g^{-1} DM]]	Soil micobial biomass C:N ratio
ST-C-1	2	19.09.13	ST	C	o	1	6.88	24.363	159.018	84.304	239.098	63.417	1.719	5.442	0.073	58.170	88.781	93.173	174.204	11.079	34.930	15.724
ST-C-2	2	19.09.13	ST	C	o	2	6.80	23.367	150.785	106.129	279.621	88.809	1.437	4.814	0.065	62.259	74.042	82.027	198.728	24.514	19.703	8.107
ST-C-3	2	19.09.13	ST	C	o	3	6.86	25.345	158.962	114.203	294.030	98.393	1.742	4.623	0.074	43.701	80.524	74.552	173.927	26.163	30.777	6.648
ST-C-4	2	19.09.13	ST	C	o	4	6.63	21.085	143.938	106.595	275.509	114.418	1.707	4.808	0.067	48.354	65.276	54.377	207.679	43.626	5.955	4.760
ST-I-1	2	19.09.13	ST	I	o	1	9.86	24.487	88.976	62.483	265.359	16.570	2.552	7.518	0.090	36.342	341.453	97.251	153.398	27.794	60.820	5.519
ST-I-2	2	19.09.13	ST	I	o	2	9.51	24.718	78.598	77.507	196.724	48.657	2.248	7.013	0.064	41.593	274.938	93.912	193.377	33.787	52.256	5.723
ST-I-3	2	19.09.13	ST	I	o	3	10.06	23.783	83.471	50.412	192.570	18.043	2.349	6.322	0.097	46.044	341.368	105.478	147.720	23.054	59.337	6.407
ST-I-4	2	19.09.13	ST	I	o	4	8.83	23.904	98.142	69.582	172.370	21.224	2.290	6.643	0.091	36.455	324.221	100.418	134.882	25.767	63.873	5.235
ST-II-1	2	19.09.13	ST	II	o	1	7.22	25.325	131.464	84.435	235.206	63.721	1.584	4.491	0.087	24.292	106.331	88.786	217.309	19.198	64.407	11.319
ST-II-2	2	19.09.13	ST	II	o	2	7.77	19.616	126.230	88.458	225.480	58.545	1.438	5.035	0.069	46.696	95.212	83.279	212.150	19.453	36.514	10.906
ST-II-3	2	19.09.13	ST	II	o	3	7.29	23.990	141.131	123.046	276.834	95.220	1.480	4.079	0.065	68.958	120.405	105.914	233.322	24.940	36.892	9.355
ST-II-4	2	19.09.13	ST	II	o	4	7.48	23.730	120.638	70.056	224.696	63.374	1.194	4.253	0.099	38.600	117.949	86.089	211.256	12.722	47.390	16.605
SU-C-1	2	19.09.13	SU	C	o	1	7.18	24.069	158.084	134.628	112.135	20.575	2.831	5.067	0.071	17.030	77.711	39.400	204.175	27.436	22.300	7.442
SU-C-2	2	19.09.13	SU	C	o	2	7.54	23.204	220.155	174.767	204.660	79.727	2.406	4.931	0.126	19.430	77.983	42.631	199.612	28.321	23.074	7.048
SU-C-3	2	19.09.13	SU	C	o	3	7.15	24.688	163.044	105.912	124.672	18.499	3.092	4.496	0.090	20.297	85.586	44.202	272.107	37.359	23.815	7.284
SU-C-4	2	19.09.13	SU	C	o	4	7.29	25.748	162.881	113.743	130.271	21.865	3.109	4.231	0.092	21.033	80.939	40.595	194.803	28.610	19.470	6.809
SU-I-1	2	19.09.13	SU	I	o	1	10.53	24.326	65.401	62.780	87.328	0.000	3.598	5.505	0.081	13.968	359.314	70.766	70.052	10.090	56.717	6.943
SU-I-2	2	19.09.13	SU	I	o	2	10.46	22.727	164.237	122.256	137.679	20.497	3.113	4.745	0.088	19.234	378.700	74.818	87.050	14.306	55.497	6.085
SU-I-3	2	19.09.13	SU	I	o	3	10.86	24.459	63.738	48.546	84.188	15.440	3.454	6.904	0.100	14.594	475.990	86.999	82.679	9.501	72.305	8.702
SU-I-4	2	19.09.13	SU	I	o	4	10.11	24.428	87.410	61.097	85.869	0.000	3.435	5.433	0.116	15.304	349.658	72.944	133.635	16.940	57.524	7.889
SU-II-1	2	19.09.13	SU	II	o	1	7.40	27.665	133.443	96.885	132.685	17.377	2.253	3.854	0.079	25.328	109.639	68.134	149.880	10.636	42.727	14.092
SU-II-2	2	19.09.13	SU	II	o	2	7.23	25.235	148.807	98.524	114.143	19.946	2.990	4.393	0.077	21.814	88.817	62.192	162.155	12.511	40.300	12.961
SU-II-3	2	19.09.13	SU	II	o	3	7.30	26.425	126.315	138.283	167.783	57.370	1.975	4.947	0.074	31.100	101.168	64.429	169.381	13.208	33.255	12.824
SU-II-4	2	19.09.13	SU	II	o	4	7.60	26.250	162.584	194.779	175.336	73.362	2.543	6.310	0.083	23.368	90.083	60.266	181.102	12.315	36.815	14.706
HA-C-1	2	19.09.13	HA	C	o	1	5.40	26.213	82.998	84.241	267.320	78.700	2.188	6.582	0.069	24.795	78.506	39.228	29.983	5.542	14.364	5.411
HA-C-2	2	19.09.13	HA	C	o	2	5.43	27.846	63.675	39.261	203.314	44.474	1.591	5.534	0.095	18.432	92.110	43.772	37.527	9.745	25.245	3.851
HA-C-3	2	19.09.13	HA	C	o	3	5.33	26.844	58.670	38.606	225.782	54.423	1.398	4.651	0.091	25.067	86.185	42.031	39.220	17.973	16.873	2.182
HA-C-4	2	19.09.13	HA	C	o	4	5.28	24.312	58.008	48.650	217.821	52.113	2.140	5.459	0.102	22.227	80.164	38.947	49.979	12.241	16.618	4.083
HA-I-1	2	19.09.13	HA	I	o	1	7.63	25.392	60.284	64.996	207.355	44.020	1.748	4.783	0.078	16.989	224.596	50.305	61.478	9.313	33.237	6.602
HA-I-2	2	19.09.13	HA	I	o	2	8.58	25.893	37.916	38.330	157.894	19.934	1.550	4.728	0.064	16.775	268.526	62.858	22.664	3.198	46.019	7.087

Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Treated layer [0-7 cm]	Repli-cate	pH	water content [% w/w]	cellulase activity [nmol $g^{-1}h^{-1}$]	exochitinase activity [nmol $g^{-1}h^{-1}$]	Phophatase activity [nmol $g^{-1}h^{-1}$]	Protease activity [nmol $g^{-1}h^{-1}$]	Phenol-oxidase activity [nmol $g^{-1}h^{-1}$]	Per-oxidase activity [nmol $g^{-1}h^{-1}$]	Am-monium [µg g^{-1} DM]	Nitrate [µg g^{-1} DM]	Dis-solved organic carbon [µg g^{-1} DM]	dissolved nitrogen [µg g^{-1} DM]	Micro-bial carbon [µg g^{-1} DM]	Micro-bial nitrogen [µg g^{-1} DM]	Dis-solved organic nitrogen [µg g^{-1} DM]]	Soil micobial biomass C:N ratio
HA-I-3	2	19.09.13	HA	I	o	3	8.14	23.961	33.166	29.283	146.445	19.558	1.753	4.497	0.119	21.542	265.595	54.612	51.125	14.446	32.952	3.539
HA-I-4	2	19.09.13	HA	I	o	4	9.01	23.884	49.093	25.734	137.049	11.474	2.632	5.067	0.082	16.809	304.132	63.033	-71.293	-4.497	46.142	15.855
HA-II-1	2	19.09.13	HA	II	o	1	7.31	27.308	69.048	52.730	135.776	23.145	1.446	2.986	0.231	25.582	103.282	41.893	47.069	10.240	16.080	4.597
HA-II-2	2	19.09.13	HA	II	o	2	7.34	24.852	86.177	63.877	244.976	68.976	1.879	5.259	0.073	10.165	101.134	36.613	59.355	7.709	26.375	7.700
HA-II-3	2	19.09.13	HA	II	o	3	6.72	26.768	56.267	41.241	151.912	25.279	1.557	2.899	0.157	19.975	121.830	43.049	25.707	9.760	22.918	2.634
HA-II-4	2	19.09.13	HA	II	o	4	6.51	25.883	60.919	51.017	199.010	34.400	2.180	3.852	0.137	18.037	137.952	43.679	33.758	13.029	25.505	2.591
ST-C-1	30	10.10.13	ST	C	o	1	6.60	22.704	106.877	130.044	222.912	31.101	1.361	4.089	0.210	76.470	74.687	67.202	185.662	32.308	-9.478	5.747
ST-C-2	30	10.10.13	ST	C	o	2	6.45	20.391	121.468	97.304	213.595	30.373	1.328	4.076	0.240	101.856	73.440	81.704	198.894	21.291	-20.392	9.342
ST-C-3	30	10.10.13	ST	C	o	3	6.65	20.204	124.178	124.583	203.162	29.185	1.104	2.969	0.190	113.790	71.542	96.773	218.295	20.581	-17.208	10.606
ST-C-4	30	10.10.13	ST	C	o	4	6.21	20.324	118.885	98.883	209.427	33.633	1.505	3.738	0.320	87.268	74.951	71.743	214.454	42.069	-15.845	5.098
ST-I-1	30	10.10.13	ST	I	o	1	7.32	21.961	84.504	98.315	147.532	24.781	1.636	3.809	0.290	119.737	160.795	109.925	143.468	25.600	-10.102	5.604
ST-I-2	30	10.10.13	ST	I	o	2	7.37	20.430	85.439	119.667	156.669	23.653	1.596	4.194	0.440	98.807	167.664	91.200	156.852	31.457	-8.047	4.986
ST-I-3	30	10.10.13	ST	I	o	3	7.05	20.657	86.980	101.898	160.118	20.208	1.960	5.032	0.190	130.914	140.958	116.195	168.630	31.796	-14.910	5.303
ST-I-4	30	10.10.13	ST	I	o	4	7.08	19.784	88.721	111.870	149.678	20.910	1.967	5.375	0.210	118.724	161.809	108.256	157.894	29.443	-10.679	5.363
ST-II-1	30	10.10.13	ST	II	o	1	6.79	20.324	149.614	86.701	236.463	50.633	1.597	3.971	0.480	85.264	97.612	75.202	179.965	29.054	-10.542	6.194
ST-II-2	30	10.10.13	ST	II	o	2	6.84	25.881	177.020	78.188	244.254	53.073	1.302	3.043	0.220	81.790	116.891	73.791	196.273	29.890	-8.219	6.567
ST-II-3	30	10.10.13	ST	II	o	3	6.80	18.116	176.253	101.832	269.741	53.688	1.547	3.416	0.230	110.150	110.731	100.434	213.083	12.711	-9.946	16.763
ST-II-4	30	10.10.13	ST	II	o	4	6.75	20.446	136.474	99.850	257.123	45.753	1.359	2.835	0.310	124.392	81.129	107.131	203.299	35.383	-17.571	5.746
SU-C-1	30	10.10.13	SU	C	o	1	7.52	21.537	129.760	100.030	125.497	23.611	2.067	4.203	0.290	28.732	84.887	45.861	199.649	44.737	16.839	4.463
SU-C-2	30	10.10.13	SU	C	o	2	7.18	21.304	107.908	106.972	121.212	24.162	1.891	3.829	0.190	21.947	77.682	37.526	207.512	42.037	15.389	4.936
SU-C-3	30	10.10.13	SU	C	o	3	7.29	20.099	116.269	110.892	122.129	22.759	1.887	3.677	0.180	13.591	74.924	32.042	241.706	43.827	18.271	5.515
SU-C-4	30	10.10.13	SU	C	o	4	6.78	20.900	123.636	104.352	119.447	29.088	1.722	3.421	0.190	30.894	84.589	46.998	206.393	30.944	15.914	6.670
SU-I-1	30	10.10.13	SU	I	o	1	7.30	22.493	108.570	112.768	114.105	27.599	2.192	2.992	0.230	53.725	110.647	69.950	170.193	33.844	15.995	5.029
SU-I-2	30	10.10.13	SU	I	o	2	7.63	23.402	141.281	135.747	120.930	27.661	2.347	3.447	0.220	44.717	141.722	71.948	300.632	49.623	27.011	6.058
SU-I-3	30	10.10.13	SU	I	o	3	8.07	19.947	102.973	139.809	96.282	25.993	2.260	3.466	0.260	50.929	139.156	65.889	166.077	44.970	14.701	3.693
SU-I-4	30	10.10.13	SU	I	o	4	7.61	22.578	116.165	136.389	103.144	29.876	2.409	3.470	0.210	41.303	135.056	78.868	147.430	20.137	37.355	7.322
SU-II-1	30	10.10.13	SU	II	o	1	7.57	22.948	163.553	124.441	156.168	36.843	1.910	3.247	0.240	30.154	85.771	47.559	195.009	34.068	17.165	5.724
SU-II-2	30	10.10.13	SU	II	o	2	7.22	21.266	171.242	126.371	145.759	37.552	2.034	3.443	0.170	28.713	67.724	43.769	207.066	36.036	14.886	5.746
SU-II-3	30	10.10.13	SU	II	o	3	6.65	21.803	169.656	125.484	173.111	36.614	1.831	3.123	0.200	35.317	84.245	48.305	316.460	46.999	12.788	6.733
SU-II-4	30	10.10.13	SU	II	o	4	7.27	21.252	174.597	150.413	160.894	38.238	1.781	2.759	0.180	25.156	69.370	38.486	220.886	36.646	13.151	6.027
HA-C-1	30	10.10.13	HA	C	o	1	5.47	19.255	51.774	61.809	487.842	88.306	1.909	4.499	0.220	22.907	100.744	38.463	72.838	20.116	15.336	3.621
HA-C-2	30	10.10.13	HA	C	o	2	5.51	19.785	40.738	44.477	438.372	83.530	1.561	3.425	0.270	18.300	66.912	33.288	96.437	15.908	14.719	6.062
HA-C-3	30	10.10.13	HA	C	o	3	5.17	18.197	43.351	48.649	481.869	92.626	1.725	4.477	0.220	15.490	57.622	30.837	120.797	21.944	15.126	5.505
HA-C-4	30	10.10.13	HA	C	o	4	5.44	18.439	63.470	57.413	493.641	74.338	1.991	4.780	0.180	26.197	67.200	40.982	94.924	19.541	14.605	4.858

Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Treated layer [0-7 cm]	Repli-cate	pH	water content [% w/w]	cellulase activity [nmol $g^{-1}h^{-1}$]	exochitinase activity [nmol $g^{-1}h^{-1}$]	Phophatase activity [nmol $g^{-1}h^{-1}$]	Protease activity [nmol $g^{-1}h^{-1}$]	Phenol-oxidase activity [nmol $g^{-1}h^{-1}$]	Per-oxidase activity [nmol $g^{-1}h^{-1}$]	Am-monium [μg g^{-1} DM]	Nitrate [μg g^{-1} DM]	Dis-solved organic carbon [μg g^{-1} DM]	dissolved nitrogen [μg g^{-1} DM]	Micro-bial carbon [μg g^{-1} DM]	Micro-bial nitrogen [μg g^{-1} DM]	Dis-solved organic nitrogen [μg g^{-1} DM]]	Soil micobial biomass C:N ratio
HA-I-1	30	10.10.13	HA	I	o	1	6.91	18.891	57.363	96.353	371.420	65.900	1.638	3.801	0.270	38.897	121.744	56.295	53.081	12.624	17.128	4.205
HA-I-2	30	10.10.13	HA	I	o	2	6.73	18.343	47.079	131.108	392.743	80.663	1.916	4.462	0.220	38.013	121.559	55.648	106.601	21.681	17.414	4.917
HA-I-3	30	10.10.13	HA	I	o	3	7.01	17.759	46.191	96.891	367.594	86.716	2.073	4.854	0.190	28.698	112.811	47.016	110.256	20.150	18.129	5.472
HA-I-4	30	10.10.13	HA	I	o	4	6.84	17.587	32.666	91.038	335.226	64.546	1.614	3.454	0.250	31.350	112.147	48.088	102.568	19.595	16.488	5.234
HA-II-1	30	10.10.13	HA	II	o	1	6.42	17.667	59.508	49.483	399.722	102.710	1.478	3.496	0.940	25.704	106.282	47.743	83.159	9.864	21.100	8.431
HA-II-2	30	10.10.13	HA	II	o	2	6.58	18.587	75.594	68.103	429.942	135.347	1.914	4.650	0.180	21.319	89.450	36.703	130.379	19.015	15.204	6.857
HA-II-3	30	10.10.13	HA	II	o	3	6.63	19.225	87.270	56.300	397.960	97.425	1.509	3.677	0.260	22.972	80.790	38.817	125.485	19.014	15.586	6.600
HA-II-4	30	10.10.13	HA	II	o	4	6.46	17.375	79.272	84.856	449.556	112.446	1.993	4.846	0.240	25.370	104.567	37.975	70.704	18.165	12.366	3.892
ST-C-1	86	12.12.13	ST	C	o	1	6.57	79.965	118.335	152.987	275.037	81.020	1.533	5.592	0.165	29.619	93.592	41.975	213.417	24.866	12.191	8.583
ST-C-2	86	12.12.13	ST	C	o	2	6.46	81.494	165.560	146.911	291.514	88.968	1.851	5.209	0.161	33.899	85.705	46.646	250.386	22.173	12.586	11.292
ST-C-3	86	12.12.13	ST	C	o	3	7.06	82.698	190.255	175.862	305.837	95.543	2.096	5.957	0.271	45.366	89.688	54.163	225.181	17.631	8.526	12.772
ST-C-4	86	12.12.13	ST	C	o	4	6.49	80.835	145.218	123.893	296.180	94.314	1.831	5.044	0.180	32.058	97.809	39.351	228.901	25.113	7.113	9.115
ST-I-1	86	12.12.13	ST	I	o	1	6.84	79.993	139.452	134.889	248.513	54.679	2.095	6.042	0.181	29.503	137.411	41.424	206.380	37.777	11.740	5.463
ST-I-2	86	12.12.13	ST	I	o	2	7.22	80.515	132.036	130.965	258.062	65.510	1.903	4.973	0.196	31.232	92.306	43.711	248.750	35.144	12.284	7.078
ST-I-3	86	12.12.13	ST	I	o	3	6.24	80.841	161.503	176.204	270.554	62.646	1.997	5.408	0.191	32.657	97.337	42.375	258.174	35.024	9.527	7.371
ST-I-4	86	12.12.13	ST	I	o	4	6.71	80.367	150.530	155.119	277.019	64.180	1.921	5.556	0.146	32.745	98.554	38.807	258.327	39.578	5.916	6.527
ST-II-1	86	12.12.13	ST	II	o	1	6.54	82.855	174.086	120.789	272.333	73.436	1.359	5.159	0.147	26.591	78.133	33.653	252.684	40.005	6.915	6.316
ST-II-2	86	12.12.13	ST	II	o	2	6.23	80.082	135.527	133.084	278.381	92.037	1.714	5.204	0.154	42.305	76.992	49.775	256.551	36.285	7.316	7.071
ST-II-3	86	12.12.13	ST	II	o	3	6.61	81.555	147.072	143.906	297.651	86.404	1.487	4.773	0.194	41.462	110.223	54.352	255.227	44.334	12.696	5.757
ST-II-4	86	12.12.13	ST	II	o	4	6.43	82.049	151.257	136.508	286.666	82.647	1.485	4.854	0.137	38.240	75.269	48.758	286.982	37.588	10.381	7.635
SU-C-1	86	12.12.13	SU	C	o	1	7.46	80.072	149.171	131.995	145.494	72.819	3.501	4.823	0.151	16.926	97.415	32.909	240.644	40.820	15.832	5.895
SU-C-2	86	12.12.13	SU	C	o	2	6.48	78.560	150.073	176.460	155.250	73.107	3.923	6.161	0.142	24.391	83.479	36.654	271.026	43.374	12.121	6.249
SU-C-3	86	12.12.13	SU	C	o	3	6.88	80.599	135.371	155.566	157.903	88.985	3.543	5.695	0.176	18.045	98.357	36.210	330.584	37.851	17.989	8.734
SU-C-4	86	12.12.13	SU	C	o	4	7.29	80.317	127.650	169.263	146.614	69.692	3.652	5.642	0.136	26.830	76.103	39.679	282.669	36.863	12.713	7.668
SU-I-1	86	12.12.13	SU	I	o	1	7.30	79.761	127.134	172.238	126.642	65.844	3.675	5.906	0.160	18.226	106.163	29.063	235.097	44.277	10.677	5.310
SU-I-2	86	12.12.13	SU	I	o	2	7.22	80.058	153.462	159.355	136.076	70.724	3.585	6.056	0.167	30.296	92.170	41.099	236.329	35.546	10.636	6.648
SU-I-3	86	12.12.13	SU	I	o	3	6.72	80.465	111.788	158.118	135.470	70.082	3.134	5.314	0.138	24.046	88.324	37.072	308.142	41.613	12.888	7.405
SU-I-4	86	12.12.13	SU	I	o	4	6.71	79.945	118.159	148.092	141.723	72.425	3.008	5.598	0.151	22.599	86.913	39.299	468.373	49.677	16.548	9.428
SU-II-1	86	12.12.13	SU	II	o	1	6.52	79.883	131.768	140.671	151.374	77.732	2.955	4.725	0.154	17.128	106.150	31.158	235.166	41.115	13.876	5.720
SU-II-2	86	12.12.13	SU	II	o	2	7.26	80.970	146.927	193.411	150.222	70.488	2.982	4.355	0.148	25.017	89.944	41.592	322.923	35.461	16.426	9.106
SU-II-3	86	12.12.13	SU	II	o	3	6.76	80.689	142.347	186.794	147.877	71.919	2.828	5.454	0.175	21.182	112.431	31.181	231.205	46.425	9.825	4.980
SU-II-4	86	12.12.13	SU	II	o	4	7.05	77.263	144.635	97.770	151.042	75.843	3.528	5.596	0.143	25.574	86.553	34.660	302.689	44.313	8.943	6.831
HA-C-1	86	12.12.13	HA	C	o	1	5.59	81.388	58.526	86.291	150.150	37.236	1.618	4.170	0.163	11.433	73.799	21.068	91.119	18.458	9.472	4.936
HA-C-2	86	12.12.13	HA	C	o	2	5.78	80.457	94.340	52.821	185.188	43.613	2.211	5.007	0.188	12.195	76.846	25.351	78.456	15.704	12.968	4.996

Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Treated layer [0-7 cm]	Repli-cate	pH	water content [% w/w]	cellulase activity [nmol $g^{-1}h^{-1}$]	exochitinase activity [nmol $g^{-1}h^{-1}$]	Phophatase activity [nmol $g^{-1}h^{-1}$]	Protease activity [nmol $g^{-1}h^{-1}$]	Phenol-oxidase activity [nmol $g^{-1}h^{-1}$]	Per-oxidase activity [nmol $g^{-1}h^{-1}$]	Am-monium [µg g^{-1} DM]	Nitrate [µg g^{-1} DM]	Dis-solved organic carbon [µg g^{-1} DM]	dissolved nitrogen [µg g^{-1} DM]	Micro-bial carbon [µg g^{-1} DM]	Micro-bial nitrogen [µg g^{-1} DM]	Dis-solved organic nitrogen [µg g^{-1} DM]]	Soil micobial biomass C:N ratio
HA-C-3	86	12.12.13	HA	C	o	3	5.74	80.964	43.430	47.036	143.196	55.020	1.469	4.119	0.134	11.803	66.968	23.986	84.276	17.489	12.049	4.819
HA-C-4	86	12.12.13	HA	C	o	4	5.45	80.454	89.462	67.989	171.408	56.936	2.366	6.027	0.145	12.714	74.148	23.841	84.885	18.129	10.981	4.682
HA-I-1	86	12.12.13	HA	I	o	1	6.46	81.394	35.116	63.839	114.496	36.334	1.694	4.166	0.154	14.312	104.062	30.862	91.753	14.897	16.397	6.159
HA-I-2	86	12.12.13	HA	I	o	2	5.98	80.061	61.116	79.132	136.972	47.174	1.952	4.949	0.164	11.983	76.652	26.845	109.056	19.020	14.698	5.734
HA-I-3	86	12.12.13	HA	I	o	3	6.08	82.432	93.225	97.845	155.653	63.832	2.550	5.903	0.152	16.539	77.463	26.727	94.805	20.683	10.037	4.584
HA-I-4	86	12.12.13	HA	I	o	4	6.61	83.091	52.345	84.601	163.208	41.131	2.297	5.020	0.122	13.495	70.060	21.126	93.190	18.947	7.509	4.919
HA-II-1	86	12.12.13	HA	II	o	1	6.55	82.012	81.240	91.952	164.003	48.174	2.344	5.384	0.763	18.946	73.963	26.822	90.683	19.663	7.113	4.612
HA-II-2	86	12.12.13	HA	II	o	2	6.00	81.135	63.014	75.076	136.411	44.720	1.966	4.515	0.134	12.657	67.621	25.469	103.124	18.356	12.678	5.618
HA-II-3	86	12.12.13	HA	II	o	3	5.75	81.416	62.462	72.156	169.520	57.491	2.444	5.777	0.139	15.421	69.690	23.054	88.930	25.696	7.495	3.461
HA-II-4	86	12.12.13	HA	II	o	4	6.27	80.367	65.633	78.072	131.322	48.773	2.303	5.766	0.138	18.617	72.007	25.856	85.704	17.232	7.102	4.974

Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Untreated layer [7-14 cm]	Repli-cate	pH	water content [% w/w]	cellulase activity [nmol $g^{-1}h^{-1}$]	exochitinase activity [nmol $g^{-1}h^{-1}$]	Phophatase activity [nmol $g^{-1}h^{-1}$]	Protease activity [nmol $g^{-1}h^{-1}$]	Phenol-oxidase activity [nmol $g^{-1}h^{-1}$]	Per-oxidase activity [nmol $g^{-1}h^{-1}$]	Am-monium [µg g^{-1} DM]	Nitrate [µg g^{-1} DM]	Dis-solved organic carbon [µg g^{-1} DM]	dissolved nitrogen [µg g^{-1} DM]	Micro-bial carbon [µg g^{-1} DM]	Micro-bial nitrogen [µg g^{-1} DM]	Dis-solved organic nitrogen [µg g^{-1} DM]]	Soil micobial biomass C:N ratio
ST-C-1	2	19.09.13	ST	C	u	1	6.82	23.309	173.888	112.524	250.922	65.563	3.236	7.365	0.072	19.295	59.274	44.643	198.157	27.290	25.276	7.261
ST-C-2	2	19.09.13	ST	C	u	2	7.12	24.256	158.241	146.059	286.683	104.893	2.044	5.835	0.066	19.985	62.626	45.737	220.518	24.211	25.686	9.108
ST-C-3	2	19.09.13	ST	C	u	3	6.80	24.641	188.047	166.703	305.620	105.743	2.327	6.780	0.069	19.992	67.184	45.824	200.154	24.129	25.763	8.295
ST-C-4	2	19.09.13	ST	C	u	4	6.63	22.945	228.898	144.348	295.477	98.378	2.637	7.138	0.068	16.877	82.144	47.593	164.237	15.653	30.648	10.492
ST-I-1	2	19.09.13	ST	I	u	1	6.52	24.752	164.323	118.936	253.795	67.862	2.220	6.726	0.090	16.308	68.679	46.676	186.315	23.273	30.279	8.006
ST-I-2	2	19.09.13	ST	I	u	2	6.89	23.469	161.016	130.755	270.026	103.142	1.759	5.163	0.063	20.853	67.281	44.128	182.992	25.185	23.211	7.266
ST-I-3	2	19.09.13	ST	I	u	3	6.33	23.602	155.999	91.974	246.363	64.424	1.760	5.725	0.097	23.294	76.484	51.117	204.342	31.749	27.726	6.436
ST-I-4	2	19.09.13	ST	I	u	4	7.06	23.063	159.763	123.753	251.808	75.081	1.656	5.477	0.090	20.078	67.131	49.373	194.778	17.769	29.204	10.962
ST-II-1	2	19.09.13	ST	II	u	1	6.88	25.000	182.889	113.850	248.677	66.147	2.067	5.362	0.087	23.832	68.053	48.310	193.531	33.665	24.391	5.749
ST-II-2	2	19.09.13	ST	II	u	2	6.97	23.094	174.598	102.121	255.945	64.139	1.809	5.587	0.071	20.391	62.789	47.421	158.463	18.356	26.959	8.633
ST-II-3	2	19.09.13	ST	II	u	3	7.89	22.466	148.113	159.731	290.442	109.327	2.137	6.468	0.064	12.239	67.096	46.845	181.767	18.245	34.542	9.962
ST-II-4	2	19.09.13	ST	II	u	4	6.90	22.800	131.357	98.678	241.009	66.288	1.708	4.644	0.098	10.507	92.247	48.248	192.408	22.555	37.643	8.531
SU-C-1	2	19.09.13	SU	C	u	1	7.42	25.047	187.327	136.097	123.759	22.388	3.714	5.396	0.071	9.381	71.689	38.252	227.051	31.325	28.800	7.248
SU-C-2	2	19.09.13	SU	C	u	2	7.39	24.411	205.499	205.841	188.820	88.767	3.858	7.665	0.127	10.351	79.243	40.691	181.866	26.001	30.213	6.995
SU-C-3	2	19.09.13	SU	C	u	3	7.23	24.346	220.120	141.449	141.811	23.677	3.838	5.399	0.090	10.152	79.423	39.008	215.075	35.003	28.765	6.145
SU-C-4	2	19.09.13	SU	C	u	4	7.20	23.352	167.519	120.691	126.981	21.525	3.611	4.739	0.090	8.244	70.203	38.884	171.704	24.280	30.550	7.072
SU-I-1	2	19.09.13	SU	I	u	1	7.68	24.658	192.614	130.931	142.516	18.107	3.218	5.103	0.081	10.560	84.453	38.269	172.085	21.532	27.628	7.992
SU-I-2	2	19.09.13	SU	I	u	2	7.71	23.779	37.318	42.066	83.446	0.000	3.774	6.057	0.088	6.400	79.298	41.462	185.634	27.470	34.973	6.758

Soil sample name	**Days after appli-cation**	**Date**	**Site**	**Treat-ment**	**Untreated layer** [7-14 cm]	**Repli-cate**	**pH**	**water content** [% w/w]	**cellulase activity** [nmol $g^{-1}h^{-1}$]	**exochitinase activity** [nmol $g^{-1}h^{-1}$]	**Phophatase activity** [nmol $g^{-1}h^{-1}$]	**Protease activity** [nmol $g^{-1}h^{-1}$]	**Phenol-oxidase activity** [nmol $g^{-1}h^{-1}$]	**Per-oxidase activity** [nmol $g^{-1}h^{-1}$]	**Am-monium** [µg g^{-1} DM]	**Nitrate** [µg g^{-1} DM]	**Dis-solved organic carbon** [µg g^{-1} DM]	**dissolved nitrogen** [µg g^{-1} DM]	**Micro-bial carbon** [µg g^{-1} DM]	**Micro-bial nitrogen** [µg g^{-1} DM]	**Dis-solved organic nitrogen** [µg g^{-1} DM]]	**Soil micobial biomass C:N ratio**
SU-I-3	2	19.09.13	SU	I	u	3	7.14	24.510	167.767	175.242	176.997	60.743	2.440	5.338	0.101	12.101	71.165	38.150	204.199	27.137	25.949	7.525
SU-I-4	2	19.09.13	SU	I	u	4	7.79	23.931	171.283	126.814	141.287	22.550	2.967	5.429	0.116	12.401	97.183	40.443	165.178	27.297	27.926	6.051
SU-II-1	2	19.09.13	SU	II	u	1	7.03	24.923	184.328	154.308	114.451	23.996	3.262	4.601	0.077	16.461	69.682	39.151	210.214	30.165	22.613	6.969
SU-II-2	2	19.09.13	SU	II	u	2	6.95	24.547	201.624	192.343	185.849	85.332	3.377	5.768	0.077	10.527	63.383	37.531	191.561	32.728	26.927	5.853
SU-II-3	2	19.09.13	SU	II	u	3	7.29	25.077	202.551	212.194	196.214	84.495	1.325	7.570	0.074	12.607	76.762	40.237	204.112	28.188	27.556	7.241
SU-II-4	2	19.09.13	SU	II	u	4	7.48	25.471	87.904	101.048	230.510	91.183	3.527	6.806	0.082	11.896	66.461	38.996	179.606	25.302	27.017	7.099
HA-C-1	2	19.09.13	HA	C	u	1	5.41	26.379	59.752	56.351	188.123	47.284	2.082	5.943	0.068	7.850	61.480	34.743	61.893	7.652	26.824	8.088
HA-C-2	2	19.09.13	HA	C	u	2	5.36	26.874	68.291	55.728	198.687	53.232	1.414	3.769	0.094	10.814	61.893	35.440	65.360	7.584	24.531	8.618
HA-C-3	2	19.09.13	HA	C	u	3	5.32	24.026	69.722	54.963	195.015	57.552	1.689	4.822	0.089	10.425	58.120	35.569	38.897	7.118	25.055	5.465
HA-C-4	2	19.09.13	HA	C	u	4	5.26	24.728	64.474	108.707	227.638	75.465	1.826	4.742	0.102	7.944	62.701	39.482	42.495	6.493	31.436	6.545
HA-I-1	2	19.09.13	HA	I	u	1	5.49	27.563	61.550	56.934	169.274	54.498	1.061	2.846	0.079	9.769	63.667	34.339	86.887	19.119	24.491	4.545
HA-I-2	2	19.09.13	HA	I	u	2	5.31	23.236	68.052	46.315	197.426	54.904	1.678	4.234	0.063	10.527	49.971	34.436	65.230	11.683	23.847	5.583
HA-I-3	2	19.09.13	HA	I	u	3	5.20	25.079	74.057	60.939	148.076	29.973	1.459	4.879	0.119	16.421	60.294	37.556	48.024	9.849	21.017	4.876
HA-I-4	2	19.09.13	HA	I	u	4	5.33	24.299	53.035	48.693	149.164	25.080	1.276	2.911	0.082	9.994	63.921	35.312	59.769	6.925	25.237	8.631
HA-II-1	2	19.09.13	HA	II	u	1	5.34	25.698	102.872	101.933	241.980	90.661	1.063	2.417	0.228	10.007	69.191	27.267	39.174	12.021	17.032	3.259
HA-II-2	2	19.09.13	HA	II	u	2	5.31	23.155	85.616	63.039	187.492	30.435	1.924	5.725	0.072	9.968	59.619	34.473	42.812	6.460	24.433	6.627
HA-II-3	2	19.09.13	HA	II	u	3	5.36	24.586	101.085	58.594	151.128	29.697	1.668	3.173	0.154	15.736	73.922	41.753	31.204	1.952	25.863	15.988
HA-II-4	2	19.09.13	HA	II	u	4	5.31	24.316	75.383	78.529	149.404	39.337	1.749	3.604	0.135	13.192	75.050	43.261	41.905	2.741	29.934	15.288
ST-C-1	30	10.10.13	ST	C	u	1	6.78	24.458	167.463	118.987	213.273	44.786	2.024	5.798	0.190	22.324	60.577	43.280	198.063	32.243	20.766	6.143
ST-C-2	30	10.10.13	ST	C	u	2	6.46	25.798	123.547	111.222	212.409	37.097	1.353	3.418	0.250	30.655	76.584	43.347	184.935	32.697	12.442	5.656
ST-C-3	30	10.10.13	ST	C	u	3	6.71	24.416	125.902	97.298	204.786	39.778	1.501	3.935	0.220	30.926	67.533	42.762	172.983	37.311	11.616	4.636
ST-C-4	30	10.10.13	ST	C	u	4	6.50	24.037	138.899	107.717	212.534	33.834	1.537	4.023	0.470	22.067	58.603	43.863	194.561	27.567	21.325	7.058
ST-I-1	30	10.10.13	ST	I	u	1	6.61	24.473	117.643	99.269	197.602	34.594	1.796	5.292	0.310	23.484	54.152	40.496	207.825	32.835	16.703	6.329
ST-I-2	30	10.10.13	ST	I	u	2	6.38	24.177	103.271	105.302	211.019	32.384	1.324	4.198	0.220	13.742	58.619	33.176	187.251	39.392	19.214	4.753
ST-I-3	30	10.10.13	ST	I	u	3	6.54	24.096	89.203	94.533	203.034	31.027	1.240	3.781	0.180	16.992	58.812	45.234	188.140	44.026	28.062	4.273
ST-I-4	30	10.10.13	ST	I	u	4	6.84	23.638	133.572	109.236	211.053	33.184	1.333	4.180	0.220	22.153	72.101	47.657	180.485	34.776	25.284	5.190
ST-II-1	30	10.10.13	ST	II	u	1	6.60	23.318	157.385	101.883	266.133	49.730	1.738	4.825	0.610	23.729	53.875	50.766	203.192	26.231	26.427	7.746
ST-II-2	30	10.10.13	ST	II	u	2	6.21	26.853	114.566	88.300	195.607	36.450	1.148	2.970	0.190	27.651	61.326	53.091	197.709	31.498	25.251	6.277
ST-II-3	30	10.10.13	ST	II	u	3	6.29	23.241	113.771	118.639	209.177	56.271	1.122	2.956	0.230	27.389	62.633	48.284	213.552	39.845	20.665	5.360
ST-II-4	30	10.10.13	ST	II	u	4	6.53	23.666	151.609	90.248	178.885	62.023	1.553	4.128	0.290	28.094	62.462	45.788	214.411	35.494	17.404	6.041
SU-C-1	30	10.10.13	SU	C	u	1	7.06	23.305	165.243	138.388	128.780	26.951	2.684	4.653	0.330	13.564	57.887	30.912	226.577	44.082	17.019	5.140
SU-C-2	30	10.10.13	SU	C	u	2	7.18	23.735	140.387	113.345	126.421	27.734	2.315	5.172	0.220	10.128	68.790	34.339	191.652	37.567	23.991	5.102
SU-C-3	30	10.10.13	SU	C	u	3	6.92	22.145	177.511	177.054	136.765	31.224	3.392	6.437	0.200	8.722	65.435	24.793	191.732	45.129	15.871	4.249
SU-C-4	30	10.10.13	SU	C	u	4	7.11	24.040	137.048	127.316	132.252	27.458	1.715	3.887	0.200	8.920	69.707	28.262	185.280	44.546	19.142	4.159

Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Untreated layer [7-14 cm]	Repli-cate	pH	water content [% w/w]	cellulase activity [nmol $g^{-1}h^{-1}$]	exochitinase activity [nmol $g^{-1}h^{-1}$]	Phophatase activity [nmol $g^{-1}h^{-1}$]	Protease activity [nmol $g^{-1}h^{-1}$]	Phenol-oxidase activity [nmol $g^{-1}h^{-1}$]	Per-oxidase activity [nmol $g^{-1}h^{-1}$]	Am-monium [µg g^{-1} DM]	Nitrate [µg g^{-1} DM]	Dis-solved organic carbon [µg g^{-1} DM]	dissolved nitrogen [µg g^{-1} DM]	Micro-bial carbon [µg g^{-1} DM]	Micro-bial nitrogen [µg g^{-1} DM]	Dis-solved organic nitrogen [µg g^{-1} DM]]	Soil micobial biomass C:N ratio
SU-I-1	30	10.10.13	SU	I	u	1	7.22	24.996	186.134	157.851	156.241	38.298	2.783	4.230	0.200	12.446	63.482	27.386	199.233	42.958	14.740	4.638
SU-I-2	30	10.10.13	SU	I	u	2	7.35	24.391	228.529	144.159	166.797	35.776	2.374	3.566	0.200	10.255	84.592	31.546	169.508	44.857	21.091	3.779
SU-I-3	30	10.10.13	SU	I	u	3	7.19	22.360	209.133	140.607	160.335	40.764	2.829	4.007	0.250	12.844	61.315	28.913	208.439	43.367	15.819	4.806
SU-I-4	30	10.10.13	SU	I	u	4	6.89	24.740	231.719	144.333	169.045	39.920	2.204	2.893	0.180	12.185	59.659	29.245	197.154	43.374	16.880	4.545
SU-II-1	30	10.10.13	SU	II	u	1	6.72	25.312	186.125	141.522	161.716	35.641	2.236	4.199	0.200	16.526	76.603	31.892	202.145	41.045	15.165	4.925
SU-II-2	30	10.10.13	SU	II	u	2	7.00	28.206	206.243	161.079	166.557	38.498	2.237	3.494	0.190	12.046	61.820	29.897	200.081	44.832	17.661	4.463
SU-II-3	30	10.10.13	SU	II	u	3	6.76	25.020	193.596	165.898	161.693	40.506	2.402	3.546	0.180	13.835	64.284	29.531	187.131	42.744	15.516	4.378
SU-II-4	30	10.10.13	SU	II	u	4	7.06	23.714	198.052	168.347	38.596	36.892	2.385	3.652	0.200	10.060	65.583	27.955	216.344	46.038	17.695	4.699
HA-C-1	30	10.10.13	HA	C	u	1	5.27	21.697	73.793	74.791	476.904	96.836	1.480	3.743	0.210	7.579	64.757	21.573	67.330	20.957	13.784	3.213
HA-C-2	30	10.10.13	HA	C	u	2	5.34	22.581	61.422	52.498	410.220	63.956	1.007	2.463	0.380	7.165	72.440	27.634	58.426	15.302	20.090	3.818
HA-C-3	30	10.10.13	HA	C	u	3	5.26	21.528	58.332	62.251	501.919	86.248	1.449	2.943	0.170	9.247	48.063	21.687	153.593	35.337	12.271	4.347
HA-C-4	30	10.10.13	HA	C	u	4	5.20	21.079	57.469	57.412	478.181	94.549	1.410	3.218	0.250	12.554	58.004	25.623	92.001	21.685	12.819	4.243
HA-I-1	30	10.10.13	HA	I	u	1	5.28	21.933	63.109	64.913	436.836	83.030	1.134	2.051	0.300	6.858	55.440	24.506	79.974	19.070	17.348	4.194
HA-I-2	30	10.10.13	HA	I	u	2	5.26	22.498	48.077	77.348	474.340	101.381	1.350	2.994	0.230	8.945	58.366	23.698	80.248	21.404	14.523	3.749
HA-I-3	30	10.10.13	HA	I	u	3	5.24	21.671	57.937	84.008	497.487	140.745	1.444	3.824	0.250	9.236	56.546	24.495	73.942	21.133	15.009	3.499
HA-I-4	30	10.10.13	HA	I	u	4	5.32	22.090	99.058	88.142	482.961	119.111	1.335	3.307	0.310	9.995	58.715	26.265	80.085	20.680	15.960	3.872
HA-II-1	30	10.10.13	HA	II	u	1	5.26	20.077	60.841	74.802	519.245	103.910	1.525	4.025	0.340	6.780	48.328	23.098	81.791	26.412	15.978	3.097
HA-II-2	30	10.10.13	HA	II	u	2	5.26	20.007	48.583	63.509	439.927	112.541	1.665	4.521	0.220	7.814	46.739	21.507	75.420	21.966	13.473	3.434
HA-II-3	30	10.10.13	HA	II	u	3	5.24	21.621	75.143	79.266	431.998	109.433	1.706	4.364	0.250	9.545	50.290	26.204	79.374	21.420	16.409	3.706
HA-II-4	30	10.10.13	HA	II	u	4	5.28	20.555	75.733	71.159	526.340	106.227	1.752	3.548	0.270	14.955	51.341	28.221	98.135	20.434	12.996	4.803
ST-C-1	86	12.12.13	ST	C	u	1	6.87	25.054	197.213	173.865	285.940	120.330	3.467	8.948	0.231	23.162	84.322	36.895	233.369	24.432	13.502	9.552
ST-C-2	86	12.12.13	ST	C	u	2	6.83	22.708	167.995	168.511	290.985	106.585	2.303	6.321	0.174	25.909	70.196	38.449	245.511	27.468	12.365	8.938
ST-C-3	86	12.12.13	ST	C	u	3	6.20	20.921	200.501	220.539	309.812	111.955	2.268	6.821	0.174	34.879	100.901	49.042	215.953	24.594	13.989	8.781
ST-C-4	86	12.12.13	ST	C	u	4	6.76	23.709	172.596	206.514	297.590	105.975	2.237	6.884	0.124	21.641	75.731	35.114	230.070	22.406	13.349	10.268
ST-I-1	86	12.12.13	ST	I	u	1	6.87	23.717	204.054	167.658	292.180	94.422	1.778	6.146	0.172	31.959	70.541	47.474	268.973	25.981	15.343	10.353
ST-I-2	86	12.12.13	ST	I	u	2	6.55	21.950	186.232	149.568	294.682	92.661	1.896	5.489	0.207	35.291	93.960	55.288	247.458	16.939	19.790	14.609
ST-I-3	86	12.12.13	ST	I	u	3	6.60	20.484	178.593	210.338	284.366	92.382	2.123	7.077	0.201	32.380	68.029	39.347	263.077	37.678	6.766	6.982
ST-I-4	86	12.12.13	ST	I	u	4	6.63	20.206	234.361	155.479	295.314	106.068	1.988	6.627	0.124	26.294	75.936	36.561	245.743	28.103	10.143	8.744
ST-II-1	86	12.12.13	ST	II	u	1	6.05	25.011	193.792	195.491	300.938	112.765	2.348	7.106	0.135	26.476	85.463	43.959	298.131	24.441	17.347	12.198
ST-II-2	86	12.12.13	ST	II	u	2	6.60	24.201	183.866	152.321	289.780	112.945	1.888	6.470	0.137	29.717	73.564	48.984	265.031	28.307	19.130	9.363
ST-II-3	86	12.12.13	ST	II	u	3	6.88	23.699	183.185	175.018	245.597	103.170	1.973	5.692	0.158	25.649	92.014	36.510	264.339	38.511	10.704	6.864
ST-II-4	86	12.12.13	ST	II	u	4	6.05	24.429	172.589	157.250	308.502	110.784	1.447	6.498	0.125	21.719	67.740	37.389	284.765	27.235	15.544	10.456
SU-C-1	86	12.12.13	SU	C	u	1	6.58	23.469	160.366	177.515	145.568	82.601	4.690	7.311	0.133	16.711	77.019	31.359	262.312	39.579	14.515	6.628
SU-C-2	86	12.12.13	SU	C	u	2	6.36	22.607	139.303	191.153	148.282	87.749	4.632	6.907	0.132	20.229	78.610	32.116	314.577	46.993	11.755	6.694

Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Untreated layer [7-14 cm]	Repli-cate	pH	water content [% w/w]	cellulase activity [nmol $g^{-1}h^{-1}$]	exochitinase activity [nmol $g^{-1}h^{-1}$]	Phophatase activity [nmol $g^{-1}h^{-1}$]	Protease activity [nmol $g^{-1}h^{-1}$]	Phenol-oxidase activity [nmol $g^{-1}h^{-1}$]	Per-oxidase activity [nmol $g^{-1}h^{-1}$]	Am-monium [µg g^{-1} DM]	Nitrate [µg g^{-1} DM]	Dis-solved organic carbon [µg g^{-1} DM]	dissolved nitrogen [µg g^{-1} DM]	Micro-bial carbon [µg g^{-1} DM]	Micro-bial nitrogen [µg g^{-1} DM]	Dis-solved organic nitrogen [µg g^{-1} DM]]	Soil micobial biomass C:N ratio
SU-C-3	86	12.12.13	SU	C	u	3	6.60	23.102	174.688	178.466	156.650	83.992	5.455	7.887	0.133	14.579	73.129	29.709	271.272	41.999	14.997	6.459
SU-C-4	86	12.12.13	SU	C	u	4	6.56	21.343	157.674	179.772	147.179	83.533	3.763	6.159	0.123	17.585	78.423	37.674	248.809	28.378	19.967	8.768
SU-I-1	86	12.12.13	SU	I	u	1	6.54	20.692	131.063	194.355	154.161	73.690	3.737	6.238	0.172	20.229	118.184	35.467	210.823	37.431	15.065	5.632
SU-I-2	86	12.12.13	SU	I	u	2	6.82	24.873	169.062	194.617	143.262	73.326	3.741	5.864	0.134	21.632	85.251	34.420	291.889	48.267	12.653	6.047
SU-I-3	86	12.12.13	SU	I	u	3	6.35	22.617	149.360	176.336	144.635	80.715	3.318	5.255	0.135	20.982	81.254	35.871	262.472	38.582	14.754	6.803
SU-I-4	86	12.12.13	SU	I	u	4	6.94	21.878	136.902	189.590	153.672	89.054	3.080	5.742	0.128	18.183	85.888	35.590	254.335	39.083	17.279	6.508
SU-II-1	86	12.12.13	SU	II	u	1	6.78	22.108	140.951	169.328	142.457	82.225	3.788	5.741	0.126	16.027	77.813	31.234	275.377	41.440	15.081	6.645
SU-II-2	86	12.12.13	SU	II	u	2	6.74	26.231	132.141	173.346	158.392	80.012	3.813	5.597	0.125	17.454	72.061	34.976	271.601	41.486	17.396	6.547
SU-II-3	86	12.12.13	SU	II	u	3	7.02	22.164	165.321	193.483	153.978	77.934	3.246	5.572	0.154	19.590	102.659	34.413	266.022	40.834	14.669	6.515
SU-II-4	86	12.12.13	SU	II	u	4	6.58	20.921	159.584	164.697	155.014	75.230	3.114	6.711	0.113	22.381	84.381	35.486	339.562	42.616	12.991	7.968
HA-C-1	86	12.12.13	HA	C	u	1	5.42	24.887	85.308	95.187	168.892	64.922	2.680	5.936	0.125	10.190	67.127	23.202	112.906	18.798	12.887	6.006
HA-C-2	86	12.12.13	HA	C	u	2	5.35	27.291	73.833	80.905	174.597	59.930	2.452	5.879	0.123	9.286	65.597	25.355	81.952	13.931	15.946	5.883
HA-C-3	86	12.12.13	HA	C	u	3	5.48	24.071	118.443	80.940	157.816	52.643	2.071	5.182	0.118	10.157	63.992	24.414	80.850	13.058	14.139	6.192
HA-C-4	86	12.12.13	HA	C	u	4	5.73	24.507	91.142	121.222	161.495	55.442	2.145	5.013	0.120	11.940	65.528	23.963	90.666	18.496	11.902	4.902
HA-I-1	86	12.12.13	HA	I	u	1	6.09	24.592	98.123	97.706	137.894	57.505	2.159	5.433	0.114	11.448	64.953	24.718	90.749	14.340	13.156	6.328
HA-I-2	86	12.12.13	HA	I	u	2	5.55	27.697	82.636	80.342	143.814	66.145	2.472	5.729	0.116	11.274	66.660	25.930	90.306	16.054	14.540	5.625
HA-I-3	86	12.12.13	HA	I	u	3	5.48	23.535	89.667	58.878	154.283	54.996	2.167	5.736	0.100	11.703	66.110	23.605	90.179	17.333	11.802	5.203
HA-I-4	86	12.12.13	HA	I	u	4	5.40	23.580	83.297	68.579	146.810	53.203	1.735	4.591	0.151	12.063	81.379	25.767	72.370	13.956	13.553	5.185
HA-II-1	86	12.12.13	HA	II	u	1	5.51	25.375	101.942	90.158	139.422	65.860	2.415	5.649	0.121	10.936	59.825	25.029	81.062	13.815	13.972	5.868
HA-II-2	86	12.12.13	HA	II	u	2	5.60	24.910	64.152	129.004	154.756	51.721	2.895	7.015	0.120	10.627	62.195	24.368	80.316	15.006	13.621	5.352
HA-II-3	86	12.12.13	HA	II	u	3	5.40	24.277	75.903	78.355	149.912	48.633	1.902	4.914	0.119	12.501	61.984	24.981	96.638	15.790	12.361	6.120
HA-II-4	86	12.12.13	HA	II	u	4	5.54	25.086	64.528	62.727	125.707	46.146	1.485	4.055	0.115	14.328	61.909	24.640	101.943	16.699	10.197	6.105

Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Treated layer [0-7 cm]	Repli-cate	14:0 [nmol g^{-1}]	i 15:0 [nmol g^{-1}]	a 15:0 [nmol g^{-1}]	15:0 [nmol g^{-1}]	2-OH 12:0 [nmol g-1]	i 16:0 [nmol g^{-1}]	i 17:0 [nmol g^{-1}]	17:0 [nmol g^{-1}]	cy 17:0 (9/10) [nmol g^{-1}]	18:0 [nmol g^{-1}]	18:1 (9) t [nmol g^{-1}]	18:1 (9) c [nmol g^{-1}]	18:2 (9,12) c [nmol g^{-1}]	19:0 [nmol g^{-1}]	cy 19:0 (9/10) [nmol g^{-1}]	20:0 [nmol g^{-1}]
ST-C-1	2	19.09.13	ST	C	o	1	0.0024	0.0089	0.0059	0.0015	0.0000	0.0039	0.0019	0.0006	0.0045	0.0067	0.0001	0.0066	0.0017	0.0084	0.0005	0.0005
ST-C-2	2	19.09.13	ST	C	o	2	0.0018	0.0060	0.0037	0.0012	0.0002	0.0025	0.0013	0.0004	0.0020	0.0073	0.0001	0.0040	0.0013	0.0084	0.0004	0.0003
ST-C-3	2	19.09.13	ST	C	o	3	0.0032	0.0162	0.0107	0.0019	0.0003	0.0076	0.0036	0.0012	0.0059	0.0093	0.0002	0.0114	0.0027	0.0084	0.0009	0.0007
ST-C-4	2	19.09.13	ST	C	o	4	0.0026	0.0119	0.0076	0.0017	0.0003	0.0054	0.0027	0.0009	0.0048	0.0098	0.0002	0.0079	0.0024	0.0084	0.0006	0.0007
ST-I-1	2	19.09.13	ST	I	o	1	0.0040	0.0000	0.0153	0.0030	0.0005	0.0099	0.0053	0.0023	0.0091	0.0124	0.0003	0.0129	0.0036	0.0084	0.0012	0.0010
ST-I-2	2	19.09.13	ST	I	o	2	0.0036	0.0119	0.0090	0.0021	0.0000	0.0064	0.0030	0.0012	0.0045	0.0143	0.0002	0.0092	0.0026	0.0084	0.0006	0.0008
ST-I-3	2	19.09.13	ST	I	o	3	0.0023	0.0088	0.0067	0.0014	0.0002	0.0044	0.0020	0.0009	0.0034	0.0078	0.0001	0.0064	0.0019	0.0084	0.0004	0.0005
ST-I-4	2	19.09.13	ST	I	o	4	0.0018	0.0081	0.0064	0.0015	0.0002	0.0038	0.0017	0.0009	0.0031	0.0066	0.0001	0.0055	0.0018	0.0084	0.0004	0.0003
ST-II-1	2	19.09.13	ST	II	o	1	0.0026	0.0107	0.0058	0.0017	0.0000	0.0045	0.0027	0.0007	0.0033	0.0090	0.0001	0.0068	0.0017	0.0084	0.0004	0.0004
ST-II-2	2	19.09.13	ST	II	o	2	0.0046	0.0183	0.0117	0.0027	0.0008	0.0087	0.0042	0.0016	0.0085	0.0287	0.0002	0.0155	0.0052	0.0084	0.0009	0.0010
ST-II-3	2	19.09.13	ST	II	o	3	0.0028	0.0148	0.0093	0.0022	0.0004	0.0064	0.0038	0.0010	0.0055	0.0091	0.0002	0.0139	0.0027	0.0084	0.0008	0.0005
ST-II-4	2	19.09.13	ST	II	o	4	0.0029	0.0081	0.0049	0.0018	0.0000	0.0046	0.0023	0.0007	0.0023	0.0099	0.0001	0.0053	0.0022	0.0084	0.0003	0.0005
SU-C-1	2	19.09.13	SU	C	o	1	0.0043	0.0210	0.0141	0.0027	0.0000	0.0091	0.0052	0.0016	0.0085	0.0129	0.0003	0.0153	0.0039	0.0084	0.0013	0.0008
SU-C-2	2	19.09.13	SU	C	o	2	0.0028	0.0136	0.0000	0.0015	0.0002	0.0034	0.0019	0.0008	0.0023	0.0116	0.0001	0.0052	0.0019	0.0084	0.0003	0.0007
SU-C-3	2	19.09.13	SU	C	o	3	0.0047	0.1102	0.0265	0.0052	0.0082	0.0000	0.0149	0.0608	0.0101	0.0016	0.1578	0.0254	0.1046	0.0084	0.0677	0.0283
SU-C-4	2	19.09.13	SU	C	o	4	0.0015	0.0045	0.0026	0.0008	0.0001	0.0019	0.0009	0.0003	0.0012	0.0061	0.0001	0.0024	0.0010	0.0084	0.0002	0.0004
SU-I-1	2	19.09.13	SU	I	o	1	0.0013	0.0019	0.0012	0.0005	0.0015	0.0008	0.0008	0.0005	0.0005	0.0000	0.0000	0.0014	0.0004	0.0084	0.0005	0.0000
SU-I-2	2	19.09.13	SU	I	o	2	0.0017	0.0033	0.0020	0.0009	0.0017	0.0014	0.0009	0.0008	0.0008	0.0000	0.0000	0.0005	0.0008	0.0084	0.0010	0.0000
SU-I-3	2	19.09.13	SU	I	o	3	0.0013	0.0023	0.0016	0.0006	0.0019	0.0009	0.0008	0.0006	0.0009	0.0000	0.0069	0.0016	0.0005	0.0084	0.0006	0.0000
SU-I-4	2	19.09.13	SU	I	o	4	0.0017	0.0036	0.0025	0.0007	0.0018	0.0014	0.0012	0.0007	0.0009	0.0000	0.0000	0.0005	0.0007	0.0084	0.0011	0.0049
SU-II-1	2	19.09.13	SU	II	o	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SU-II-2	2	19.09.13	SU	II	o	2	0.0037	0.0167	0.0093	0.0022	0.0000	0.0076	0.0043	0.0011	0.0054	0.0130	0.0002	0.0117	0.0031	0.0084	0.0009	0.0007
SU-II-3	2	19.09.13	SU	II	o	3	0.0016	0.0048	0.0027	0.0008	0.0001	0.0021	0.0011	0.0003	0.0014	0.0088	0.0001	0.0031	0.0010	0.0084	0.0002	0.0004
SU-II-4	2	19.09.13	SU	II	o	4	0.0075	0.0203	0.0115	0.0024	0.0006	0.0085	0.0050	0.0013	0.0062	0.0112	0.0003	0.0130	0.0038	0.0084	0.0008	0.0008
HA-C-1	2	19.09.13	HA	C	o	1	0.0026	0.0060	0.0029	0.0020	0.0000	0.0023	0.0013	0.0004	0.0013	0.0091	0.0001	0.0040	0.0014	0.0084	0.0002	0.0004
HA-C-2	2	19.09.13	HA	C	o	2	0.0022	0.0092	0.0052	0.0014	0.0000	0.0041	0.0019	0.0007	0.0028	0.0088	0.0001	0.0064	0.0022	0.0084	0.0004	0.0004
HA-C-3	2	19.09.13	HA	C	o	3	0.0002	0.0056	0.0031	0.0012	0.0000	0.0023	0.0011	0.0004	0.0015	0.0075	0.0001	0.0030	0.0011	0.0084	0.0001	0.0003
HA-C-4	2	19.09.13	HA	C	o	4	0.0037	0.0148	0.0089	0.0021	0.0003	0.0065	0.0032	0.0010	0.0047	0.0115	0.0002	0.0082	0.0029	0.0084	0.0006	0.0011
HA-I-1	2	19.09.13	HA	I	o	1	0.0022	0.0064	0.0039	0.0010	0.0001	0.0028	0.0015	0.0007	0.0018	0.0083	0.0001	0.0035	0.0013	0.0084	0.0002	0.0005
HA-I-2	2	19.09.13	HA	I	o	2	0.0014	0.0044	0.0032	0.0011	0.0001	0.0019	0.0010	0.0000	0.0011	0.0057	0.0001	0.0026	0.0010	0.0084	0.0001	0.0003
HA-I-3	2	19.09.13	HA	I	o	3	0.0005	0.0069	0.0051	0.0014	0.0002	0.0027	0.0014	0.0000	0.0019	0.0093	0.0001	0.0034	0.0014	0.0084	0.0002	0.0003
HA-I-4	2	19.09.13	HA	I	o	4	0.0165	0.1594	0.0495	0.0035	0.0324	0.0000	0.0225	0.0644	0.0188	0.0022	0.1295	0.0100	0.1758	0.0084	0.0924	0.0000
HA-II-1	2	19.09.13	HA	II	o	1	0.0030	0.0094	0.0055	0.0016	0.0000	0.0040	0.0020	0.0010	0.0030	0.0097	0.0001	0.0055	0.0020	0.0084	0.0003	0.0008
HA-II-2	2	19.09.13	HA	II	o	2	0.0017	0.0053	0.0030	0.0012	0.0001	0.0021	0.0010	0.0002	0.0015	0.0065	0.0001	0.0040	0.0013	0.0084	0.0000	0.0002
HA-II-3	2	19.09.13	HA	II	o	3	0.0026	0.0112	0.0063	0.0016	0.0000	0.0052	0.0029	0.0010	0.0034	0.0116	0.0002	0.0075	0.0019	0.0084	0.0004	0.0006
HA-II-4	2	19.09.13	HA	II	o	4	0.0030	0.0118	0.0064	0.0018	0.0001	0.0050	0.0028	0.0009	0.0037	0.0119	0.0002	0.0078	0.0023	0.0084	0.0005	0.0006

Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Treated layer [0-7 cm]	Repli-cate	14:0 [nmol g^{-1}]	i 15:0 [nmol g^{-1}]	a 15:0 [nmol g^{-1}]	15:0 [nmol g^{-1}]	2-OH 12:0 [nmol g-1]	i 16:0 [nmol g^{-1}]	i 17:0 [nmol g^{-1}]	17:0 [nmol g^{-1}]	cy 17:0 (9/10) [nmol g^{-1}]	18:0 [nmol g^{-1}]	18:1 (9) t [nmol g^{-1}]	18:1 (9) c [nmol g^{-1}]	18:2 (9,12) c [nmol g^{-1}]	19:0 [nmol g^{-1}]	cy 19:0 (9/10) [nmol g^{-1}]	20:0 [nmol g^{-1}]
ST-C-1	30	10.10.13	ST	C	o	1	0.0029	0.0102	0.0065	0.0018	0.0005	0.0050	0.0026	0.0011	0.0011	0.0216	0.0002	0.0082	0.0028	0.0084	0.0006	0.0008
ST-C-2	30	10.10.13	ST	C	o	2	0.0058	0.0232	0.0152	0.0035	0.0008	0.0109	0.0055	0.0022	0.0091	0.0317	0.0003	0.0180	0.0051	0.0084	0.0014	0.0015
ST-C-3	30	10.10.13	ST	C	o	3	0.0043	0.0147	0.0086	0.0025	0.0008	0.0074	0.0035	0.0039	0.0008	0.0245	0.0002	0.0108	0.0044	0.0084	0.0005	0.0007
ST-C-4	30	10.10.13	ST	C	o	4	0.0031	0.0118	0.0075	0.0020	0.0006	0.0057	0.0028	0.0014	0.0045	0.0263	0.0002	0.0098	0.0029	0.0084	0.0006	0.0008
ST-I-1	30	10.10.13	ST	I	o	1	0.0021	0.0069	0.0045	0.0012	0.0003	0.0036	0.0016	0.0012	0.0026	0.0199	0.0001	0.0058	0.0018	0.0084	0.0003	0.0005
ST-I-2	30	10.10.13	ST	I	o	2	0.0038	0.0140	0.0095	0.0022	0.0005	0.0076	0.0035	0.0017	0.0056	0.0312	0.0003	0.0122	0.0038	0.0084	0.0000	0.0010
ST-I-3	30	10.10.13	ST	I	o	3	0.0021	0.0084	0.0057	0.0011	0.0019	0.0030	0.0024	0.0011	0.0006	0.0000	0.0000	0.0000	0.0015	0.0084	0.0036	0.0000
ST-I-4	30	10.10.13	ST	I	o	4	0.0043	0.0173	0.0117	0.0024	0.0005	0.0087	0.0040	0.0016	0.0067	0.0193	0.0002	0.0129	0.0043	0.0084	0.0008	0.0009
ST-II-1	30	10.10.13	ST	II	o	1	0.0025	0.0082	0.0050	0.0016	0.0003	0.0040	0.0018	0.0011	0.0029	0.0141	0.0001	0.0059	0.0015	0.0084	0.0004	0.0005
ST-II-2	30	10.10.13	ST	II	o	2	0.0064	0.0302	0.0195	0.0036	0.0011	0.0134	0.0071	0.0025	0.0118	0.0368	0.0000	0.0225	0.0062	0.0084	0.0015	0.0016
ST-II-3	30	10.10.13	ST	II	o	3	0.0051	0.0215	0.0143	0.0028	0.0007	0.0097	0.0051	0.0019	0.0083	0.0281	0.0003	0.0164	0.0047	0.0084	0.0012	0.0011
ST-II-4	30	10.10.13	ST	II	o	4	0.0027	0.0103	0.0064	0.0018	0.0004	0.0051	0.0024	0.0013	0.0036	0.0160	0.0001	0.0075	0.0024	0.0084	0.0005	0.0006
SU-C-1	30	10.10.13	SU	C	o	1	0.0030	0.0127	0.0070	0.0017	0.0003	0.0057	0.0035	0.0015	0.0041	0.0148	0.0002	0.0085	0.0028	0.0084	0.0005	0.0005
SU-C-2	30	10.10.13	SU	C	o	2	0.0037	0.0146	0.0082	0.0021	0.0005	0.0065	0.0035	0.0013	0.0054	0.0261	0.0002	0.0112	0.0031	0.0084	0.0006	0.0008
SU-C-3	30	10.10.13	SU	C	o	3	0.0031	0.0113	0.0060	0.0021	0.0007	0.0054	0.0027	0.0012	0.0005	0.0244	0.0000	0.0085	0.0035	0.0084	0.0003	0.0007
SU-C-4	30	10.10.13	SU	C	o	4	0.0063	0.0277	0.0161	0.0033	0.0011	0.0114	0.0077	0.0029	0.0090	0.0288	0.0002	0.0201	0.0074	0.0084	0.0011	0.0014
SU-I-1	30	10.10.13	SU	I	o	1	0.0035	0.0123	0.0077	0.0022	0.0007	0.0062	0.0030	0.0014	0.0047	0.0204	0.0002	0.0093	0.0025	0.0084	0.0006	0.0008
SU-I-2	30	10.10.13	SU	I	o	2	0.0039	0.0116	0.0067	0.0020	0.0006	0.0061	0.0028	0.0012	0.0042	0.0212	0.0001	0.0092	0.0035	0.0084	0.0004	0.0008
SU-I-3	30	10.10.13	SU	I	o	3	0.0041	0.0143	0.0085	0.0023	0.0003	0.0069	0.0034	0.0013	0.0059	0.0241	0.0002	0.0112	0.0041	0.0084	0.0004	0.0008
SU-I-4	30	10.10.13	SU	I	o	4	0.0038	0.0137	0.0080	0.0021	0.0005	0.0064	0.0034	0.0033	0.0006	0.0308	0.0002	0.0126	0.0073	0.0084	0.0004	0.0009
SU-II-1	30	10.10.13	SU	II	o	1	0.0043	0.0175	0.0094	0.0028	0.0011	0.0078	0.0043	0.0015	0.0057	0.0253	0.0000	0.0121	0.0040	0.0084	0.0006	0.0010
SU-II-2	30	10.10.13	SU	II	o	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SU-II-3	30	10.10.13	SU	II	o	3	0.0033	0.0115	0.0064	0.0016	0.0006	0.0050	0.0027	0.0011	0.0006	0.0252	0.0000	0.0091	0.0039	0.0084	0.0004	0.0006
SU-II-4	30	10.10.13	SU	II	o	4	0.0033	0.0123	0.0072	0.0020	0.0009	0.0057	0.0032	0.0013	0.0047	0.0224	0.0003	0.0105	0.0033	0.0084	0.0005	0.0005
HA-C-1	30	10.10.13	HA	C	o	1	0.0031	0.0090	0.0056	0.0015	0.0002	0.0043	0.0019	0.0011	0.0031	0.0162	0.0002	0.0067	0.0031	0.0084	0.0003	0.0006
HA-C-2	30	10.10.13	HA	C	o	2	0.0024	0.0045	0.0024	0.0011	0.0002	0.0024	0.0010	0.0007	0.0013	0.0239	0.0000	0.0039	0.0017	0.0084	0.0002	0.0006
HA-C-3	30	10.10.13	HA	C	o	3	0.0014	0.0014	0.0009	0.0012	0.0004	0.0014	0.0003	0.0005	0.0005	0.0160	0.0001	0.0018	0.0006	0.0084	0.0000	0.0003
HA-C-4	30	10.10.13	HA	C	o	4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
HA-I-1	30	10.10.13	HA	I	o	1	0.0032	0.0056	0.0033	0.0016	0.0006	0.0033	0.0021	0.0008	0.0004	0.0287	0.0000	0.0051	0.0022	0.0084	0.0002	0.0007
HA-I-2	30	10.10.13	HA	I	o	2	0.0067	0.0178	0.0115	0.0031	0.0007	0.0090	0.0039	0.0018	0.0067	0.0356	0.0002	0.0143	0.0064	0.0084	0.0007	0.0014
HA-I-3	30	10.10.13	HA	I	o	3	0.0039	0.0087	0.0050	0.0016	0.0003	0.0047	0.0019	0.0008	0.0032	0.0281	0.0001	0.0079	0.0033	0.0084	0.0003	0.0010
HA-I-4	30	10.10.13	HA	I	o	4	0.0028	0.0078	0.0046	0.0014	0.0002	0.0037	0.0017	0.0014	0.0025	0.0140	0.0001	0.0051	0.0019	0.0084	0.0002	0.0007
HA-II-1	30	10.10.13	HA	II	o	1	0.0025	0.0052	0.0029	0.0012	0.0007	0.0028	0.0011	0.0008	0.0019	0.0332	0.0001	0.0054	0.0020	0.0084	0.0002	0.0009

Soil	Days after	Date	Site	Treat-	Treated	Repli-	14:0	i 15:0	a 15:0	15:0	2-OH 12:0	i 16:0	i 17:0	17:0	cy 17:0	18:0	18:1 (9) t	18:1 (9) c	18:2	19:0	cy 19:0	20:0

sample name	appli- cation			ment	layer [0-7 cm]	cate	[nmol g^{-1}]	[nmol g^{-1}]	[nmol g^{-1}]	[nmol g^{-1}]	[nmol g-1]	[nmol g^{-1}]	[nmol g^{-1}]	[nmol g^{-1}]	(9/10) [nmol g^{-1}]	[nmol g^{-1}]	[nmol g^{-1}]	[nmol g^{-1}]	(9,12) c [nmol g^{-1}]	[nmol g^{-1}]	(9/10) [nmol g^{-1}]	[nmol g^{-1}]
HA-II-2	30	10.10.13	HA	II	o	2	0.0027	0.0074	0.0045	0.0018	0.0006	0.0040	0.0023	0.0011	0.0027	0.0321	0.0000	0.0063	0.0024	0.0084	0.0002	0.0007
HA-II-3	30	10.10.13	HA	II	o	3	0.0043	0.0120	0.0070	0.0019	0.0008	0.0054	0.0026	0.0012	0.0040	0.0294	0.0000	0.0084	0.0042	0.0084	0.0004	0.0010
HA-II-4	30	10.10.13	HA	II	o	4	0.0041	0.0135	0.0083	0.0023	0.0006	0.0065	0.0032	0.0016	0.0048	0.0259	0.0000	0.0094	0.0036	0.0084	0.0004	0.0009
ST-C-1	86	12.12.13	ST	C	o	1	0.0026	0.0113	0.0078	0.0013	0.0016	0.0038	0.0027	0.0014	0.0000	0.0000	0.0000	0.0027	0.0017	0.0084	0.0049	0.0000
ST-C-2	86	12.12.13	ST	C	o	2	0.0019	0.0073	0.0048	0.0011	0.0016	0.0026	0.0021	0.0011	0.0006	0.0000	0.0016	0.0000	0.0012	0.0084	0.0031	0.0005
ST-C-3	86	12.12.13	ST	C	o	3	0.0018	0.0059	0.0040	0.0009	0.0016	0.0021	0.0018	0.0009	0.0005	0.0000	0.0000	0.0015	0.0008	0.0084	0.0024	0.0000
ST-C-4	86	12.12.13	ST	C	o	4	0.0024	0.0094	0.0062	0.0012	0.0015	0.0032	0.0000	0.0010	0.0008	0.0000	0.0000	0.0025	0.0014	0.0084	0.0040	0.0003
ST-I-1	86	12.12.13	ST	I	o	1	0.0024	0.0099	0.0067	0.0012	0.0020	0.0036	0.0029	0.0013	0.0009	0.0000	0.0000	0.0025	0.0015	0.0084	0.0042	0.0000
ST-I-2	86	12.12.13	ST	I	o	2	0.0000	0.0050	0.0035	0.0009	0.0018	0.0016	0.0014	0.0008	0.0016	0.0000	0.0000	0.0011	0.0008	0.0084	0.0020	0.0016
ST-I-3	86	12.12.13	ST	I	o	3	0.0021	0.0084	0.0057	0.0011	0.0019	0.0030	0.0024	0.0011	0.0006	0.0000	0.0000	0.0000	0.0015	0.0084	0.0036	0.0000
ST-I-4	86	12.12.13	ST	I	o	4	0.0015	0.0065	0.0044	0.0010	0.0016	0.0022	0.0018	0.0008	0.0027	0.0000	0.0000	0.0016	0.0010	0.0084	0.0029	0.0000
ST-II-1	86	12.12.13	ST	II	o	1	0.0019	0.0072	0.0051	0.0010	0.0017	0.0025	0.0020	0.0009	0.0005	0.0000	0.0000	0.0018	0.0000	0.0084	0.0031	0.0010
ST-II-2	86	12.12.13	ST	II	o	2	0.0020	0.0083	0.0056	0.0010	0.0017	0.0029	0.0023	0.0008	0.0007	0.0000	0.0022	0.0000	0.0012	0.0084	0.0038	0.0000
ST-II-3	86	12.12.13	ST	II	o	3	0.0020	0.0073	0.0049	0.0009	0.0016	0.0025	0.0021	0.0009	0.0006	0.0000	0.0000	0.0019	0.0011	0.0084	0.0006	0.0007
ST-II-4	86	12.12.13	ST	II	o	4	0.0024	0.0109	0.0071	0.0011	0.0018	0.0036	0.0027	0.0012	0.0008	0.0000	0.0000	0.0029	0.0016	0.0084	0.0047	0.0000
SU-C-1	86	12.12.13	SU	C	o	1	0.0020	0.0068	0.0042	0.0009	0.0017	0.0022	0.0019	0.0007	0.0019	0.0000	0.0000	0.0010	0.0008	0.0084	0.0022	0.0000
SU-C-2	86	12.12.13	SU	C	o	2	0.0020	0.0086	0.0051	0.0009	0.0017	0.0026	0.0021	0.0008	0.0030	0.0000	0.0000	0.0012	0.0010	0.0084	0.0028	0.0000
SU-C-3	86	12.12.13	SU	C	o	3	0.0025	0.0104	0.0063	0.0013	0.0017	0.0036	0.0030	0.0010	0.0005	0.0000	0.0000	0.0017	0.0013	0.0084	0.0036	0.0000
SU-C-4	86	12.12.13	SU	C	o	4	0.0033	0.0095	0.0054	0.0017	0.0001	0.0047	0.0023	0.0013	0.0026	0.0000	0.0001	0.0068	0.0020	0.0084	0.0004	0.0006
SU-I-1	86	12.12.13	SU	I	o	1	0.0036	0.0122	0.0081	0.0019	0.0004	0.0057	0.0025	0.0012	0.0042	0.0199	0.0002	0.0071	0.0013	0.0084	0.0006	0.0007
SU-I-2	86	12.12.13	SU	I	o	2	0.0052	0.0194	0.0113	0.0025	0.0005	0.0089	0.0045	0.0020	0.0060	0.0250	0.0002	0.0152	0.0042	0.0084	0.0008	0.0011
SU-I-3	86	12.12.13	SU	I	o	3	0.0039	0.0116	0.0067	0.0018	0.0004	0.0058	0.0028	0.0013	0.0033	0.0213	0.0001	0.0085	0.0022	0.0084	0.0004	0.0008
SU-I-4	86	12.12.13	SU	I	o	4	0.0031	0.0102	0.0056	0.0015	0.0003	0.0051	0.0023	0.0014	0.0028	0.0201	0.0002	0.0077	0.0021	0.0084	0.0004	0.0008
SU-II-1	86	12.12.13	SU	II	o	1	0.0037	0.0117	0.0067	0.0016	0.0003	0.0056	0.0036	0.0017	0.0033	0.0228	0.0001	0.0088	0.0020	0.0084	0.0004	0.0008
SU-II-2	86	12.12.13	SU	II	o	2	0.0051	0.0207	0.0120	0.0026	0.0005	0.0095	0.0046	0.0019	0.0062	0.0272	0.0003	0.0141	0.0034	0.0084	0.0008	0.0012
SU-II-3	86	12.12.13	SU	II	o	3	0.0033	0.0090	0.0049	0.0013	0.0004	0.0043	0.0020	0.0014	0.0024	0.0200	0.0002	0.0072	0.0019	0.0084	0.0003	0.0006
SU-II-4	86	12.12.13	SU	II	o	4	0.0034	0.0083	0.0049	0.0014	0.0000	0.0044	0.0021	0.0000	0.0023	0.0218	0.0002	0.0065	0.0017	0.0084	0.0003	0.0006
HA-C-1	86	12.12.13	HA	C	o	1	0.0029	0.0039	0.0021	0.0013	0.0001	0.0025	0.0008	0.0012	0.0008	0.0216	0.0001	0.0032	0.0009	0.0084	0.0000	0.0007
HA-C-2	86	12.12.13	HA	C	o	2	0.0032	0.0080	0.0047	0.0013	0.0000	0.0039	0.0016	0.0016	0.0022	0.0215	0.0001	0.0060	0.0016	0.0084	0.0002	0.0008
HA-C-3	86	12.12.13	HA	C	o	3	0.0029	0.0079	0.0043	0.0011	0.0001	0.0039	0.0017	0.0015	0.0030	0.0209	0.0001	0.0058	0.0016	0.0084	0.0003	0.0009
HA-C-4	86	12.12.13	HA	C	o	4	0.0030	0.0054	0.0029	0.0012	0.0003	0.0029	0.0011	0.0014	0.0013	0.0225	0.0000	0.0040	0.0010	0.0084	0.0002	0.0007
HA-I-1	86	12.12.13	HA	I	o	1	0.0037	0.0086	0.0053	0.0015	0.0003	0.0042	0.0017	0.0017	0.0025	0.0282	0.0002	0.0064	0.0018	0.0084	0.0002	0.0008
HA-I-2	86	12.12.13	HA	I	o	2	0.0037	0.0078	0.0047	0.0014	0.0001	0.0040	0.0016	0.0013	0.0022	0.0221	0.0002	0.0059	0.0018	0.0084	0.0002	0.0008
HA-I-3	86	12.12.13	HA	I	o	3	0.0031	0.0075	0.0044	0.0014	0.0000	0.0037	0.0015	0.0015	0.0021	0.0226	0.0001	0.0055	0.0016	0.0084	0.0002	0.0007
HA-I-4	86	12.12.13	HA	I	o	4	0.0031	0.0058	0.0032	0.0012	0.0002	0.0034	0.0013	0.0012	0.0015	0.0223	0.0001	0.0048	0.0015	0.0084	0.0001	0.0007
Soil sample	Days after appli-	Date	Site	Treat- ment	Treated layer	Repli- cate	14:0 [nmol g	i 15:0 [nmol g	a 15:0 [nmol g^{-1}]	15:0 [nmol g^{-1}]	2-OH 12:0 [nmol g-1]	i 16:0 [nmol g^{-1}]	i 17:0 [nmol g^{-1}]	17:0 [nmol g^{-1}]	cy 17:0 (9/10)	18:0 [nmol g^{-1}]	18:1 (9) t [nmol g^{-1}]	18:1 (9) c [nmol g^{-1}]	18:2 (9,12) c	19:0 [nmol g	cy 19:0 (9/10)	20:0 [nmol g

name	cation				[0-7 cm]		^{1}]	^{1}]							[nmol g^{-1}]				[nmol g^{-} ^{1}]	^{1}]	[nmol g^{-} ^{1}]	^{1}]
HA-II-1	86	12.12.13	HA	II	o	1	0.0031	0.0080	0.0047	0.0012	0.0001	0.0041	0.0016	0.0013	0.0023	0.0255	0.0002	0.0059	0.0018	0.0084	0.0002	0.0008
HA-II-2	86	12.12.13	HA	II	o	2	0.0026	0.0051	0.0029	0.0010	0.0000	0.0029	0.0010	0.0010	0.0014	0.0247	0.0001	0.0049	0.0016	0.0084	0.0001	0.0006
HA-II-3	86	12.12.13	HA	II	o	3	0.0032	0.0056	0.0031	0.0013	0.0000	0.0031	0.0010	0.0010	0.0013	0.0254	0.0001	0.0048	0.0017	0.0084	0.0002	0.0007
HA-II-4	86	12.12.13	HA	II	o	4	0.0036	0.0070	0.0043	0.0015	0.0000	0.0037	0.0015	0.0010		0.0266	0.0002	0.0059	0.0018	0.0084	0.0002	0.0008

Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Treated layer [0-7 cm]	Repli-cate	gram + [nmol g^{-1}]	gram - [nmol g^{-1}]	fungi [nmol g^{-1}]	unspecific bacteria [nmol g^{-1}]	protozoa [nmol g^{-1}]	fungi : bacteria	gram + : gram -
ST-C-1	2	19.09.13	ST	C	o	1	0.0206	0.0079	0.0084	0.0082	0.0005	0.2284	2.6034
ST-C-2	2	19.09.13	ST	C	o	2	0.0134	0.0046	0.0055	0.0086	0.0003	0.2061	2.9393
ST-C-3	2	19.09.13	ST	C	o	3	0.0381	0.0111	0.0143	0.0114	0.0007	0.2354	3.4185
ST-C-4	2	19.09.13	ST	C	o	4	0.0277	0.0088	0.0104	0.0117	0.0007	0.2159	3.1314
ST-I-1	2	19.09.13	ST	I	o	1	0.0305	0.0165	0.0168	0.0158	0.0010	0.2662	1.8452
ST-I-2	2	19.09.13	ST	I	o	2	0.0303	0.0099	0.0120	0.0164	0.0008	0.2117	3.0654
ST-I-3	2	19.09.13	ST	I	o	3	0.0220	0.0070	0.0084	0.0094	0.0005	0.2192	3.1301
ST-I-4	2	19.09.13	ST	I	o	4	0.0200	0.0062	0.0073	0.0083	0.0003	0.2126	3.2205
ST-II-1	2	19.09.13	ST	II	o	1	0.0238	0.0070	0.0086	0.0106	0.0004	0.2074	3.3890
ST-II-2	2	19.09.13	ST	II	o	2	0.0429	0.0157	0.0209	0.0322	0.0010	0.2302	2.7349
ST-II-3	2	19.09.13	ST	II	o	3	0.0343	0.0101	0.0168	0.0117	0.0005	0.2987	3.3866
ST-II-4	2	19.09.13	ST	II	o	4	0.0199	0.0063	0.0076	0.0117	0.0005	0.2005	3.1878
SU-C-1	2	19.09.13	SU	C	o	1	0.0495	0.0157	0.0194	0.0156	0.0008	0.2404	3.1528
SU-C-2	2	19.09.13	SU	C	o	2	0.0189	0.0062	0.0072	0.0133	0.0007	0.1877	3.0445
SU-C-3	2	19.09.13	SU	C	o	3	0.1517	0.1433	0.2879	0.0151	0.0283	0.9284	1.0583
SU-C-4	2	19.09.13	SU	C	o	4	0.0099	0.0033	0.0034	0.0070	0.0004	0.1692	2.9862
SU-I-1	2	19.09.13	SU	I	o	1	0.0047	0.0029	0.0018	0.0020	0.0000	0.1908	1.6544
SU-I-2	2	19.09.13	SU	I	o	2	0.0076	0.0042	0.0012	0.0026	0.0000	0.0866	1.7934
SU-I-3	2	19.09.13	SU	I	o	3	0.0056	0.0034	0.0091	0.0024	0.0000	0.8005	1.6724
SU-I-4	2	19.09.13	SU	I	o	4	0.0086	0.0044	0.0012	0.0026	0.0049	0.0779	1.9551
SU-II-1	2	19.09.13	SU	II	o	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SU-II-2	2	19.09.13	SU	II	o	2	0.0379	0.0110	0.0150	0.0152	0.0007	0.2338	3.4482
SU-II-3	2	19.09.13	SU	II	o	3	0.0108	0.0036	0.0042	0.0096	0.0004	0.1733	3.0336
SU-II-4	2	19.09.13	SU	II	o	4	0.0452	0.0159	0.0171	0.0141	0.0008	0.2274	2.8439
HA-C-1	2	19.09.13	HA	C	o	1	0.0124	0.0045	0.0054	0.0110	0.0004	0.1942	2.7822
HA-C-2	2	19.09.13	HA	C	o	2	0.0204	0.0061	0.0088	0.0102	0.0004	0.2391	3.3442
HA-C-3	2	19.09.13	HA	C	o	3	0.0120	0.0022	0.0042	0.0087	0.0003	0.1823	5.5034
Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Treated layer [0-7 cm]	Repli-cate	gram + [nmol g^{-1}]	gram - [nmol g^{-1}]	fungi [nmol g^{-1}]	unspecific bacteria [nmol g^{-1}]	protozoa [nmol g^{-1}]	fungi : bacteria	gram + : gram -

Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Treated layer [0-7 cm]	Repli-cate	gram + [nmol g^{-1}]	gram - [nmol g^{-1}]	fungi [nmol g^{-1}]	unspecific bacteria [nmol g^{-1}]	protozoa [nmol g^{-1}]	fungi : bacteria	gram + : gram -
HA-C-4	2	19.09.13	HA	C	o	4	0.0334	0.0100	0.0113	0.0139	0.0011	0.1966	3.3272
HA-I-1	2	19.09.13	HA	I	o	1	0.0146	0.0049	0.0050	0.0095	0.0005	0.1712	2.9776
HA-I-2	2	19.09.13	HA	I	o	2	0.0105	0.0026	0.0037	0.0068	0.0003	0.1834	3.9883
HA-I-3	2	19.09.13	HA	I	o	3	0.0161	0.0026	0.0050	0.0109	0.0003	0.1678	6.1822
HA-I-4	2	19.09.13	HA	I	o	4	0.2314	0.1922	0.3153	0.0381	0.0000	0.6829	1.2042
HA-II-1	2	19.09.13	HA	II	o	1	0.0209	0.0074	0.0077	0.0113	0.0008	0.1937	2.8260
HA-II-2	2	19.09.13	HA	II	o	2	0.0115	0.0034	0.0053	0.0078	0.0002	0.2327	3.3412
HA-II-3	2	19.09.13	HA	II	o	3	0.0257	0.0074	0.0096	0.0132	0.0006	0.2078	3.4794
HA-II-4	2	19.09.13	HA	II	o	4	0.0260	0.0081	0.0103	0.0138	0.0006	0.2157	3.2196
ST-C-1	30	10.10.13	ST	C	o	1	0.0242	0.0057	0.0112	0.0239	0.0008	0.2079	4.2834
ST-C-2	30	10.10.13	ST	C	o	2	0.0548	0.0185	0.0233	0.0360	0.0015	0.2135	2.9697
ST-C-3	30	10.10.13	ST	C	o	3	0.0343	0.0094	0.0154	0.0279	0.0007	0.2149	3.6455
ST-C-4	30	10.10.13	ST	C	o	4	0.0278	0.0096	0.0129	0.0289	0.0008	0.1943	2.8998
ST-I-1	30	10.10.13	ST	I	o	1	0.0166	0.0063	0.0076	0.0214	0.0005	0.1723	2.6255
ST-I-2	30	10.10.13	ST	I	o	2	0.0347	0.0111	0.0162	0.0339	0.0010	0.2035	3.1211
ST-I-3	30	10.10.13	ST	I	o	3	0.0195	0.0075	0.0015	0.0029	0.0000	0.0509	2.6123
ST-I-4	30	10.10.13	ST	I	o	4	0.0417	0.0134	0.0174	0.0222	0.0009	0.2256	3.1065
ST-II-1	30	10.10.13	ST	II	o	1	0.0189	0.0069	0.0075	0.0160	0.0005	0.1798	2.7432
ST-II-2	30	10.10.13	ST	II	o	2	0.0702	0.0223	0.0287	0.0415	0.0016	0.2143	3.1547
ST-II-3	30	10.10.13	ST	II	o	3	0.0505	0.0165	0.0215	0.0316	0.0011	0.2180	3.0559
ST-II-4	30	10.10.13	ST	II	o	4	0.0241	0.0080	0.0101	0.0182	0.0006	0.2002	2.9970
SU-C-1	30	10.10.13	SU	C	o	1	0.0289	0.0091	0.0115	0.0169	0.0005	0.2098	3.1556
SU-C-2	30	10.10.13	SU	C	o	2	0.0327	0.0109	0.0144	0.0288	0.0008	0.1995	3.0016
SU-C-3	30	10.10.13	SU	C	o	3	0.0254	0.0052	0.0120	0.0272	0.0007	0.2075	4.9006
SU-C-4	30	10.10.13	SU	C	o	4	0.0630	0.0192	0.0277	0.0331	0.0014	0.2402	3.2782
SU-I-1	30	10.10.13	SU	I	o	1	0.0292	0.0102	0.0120	0.0234	0.0008	0.1908	2.8735
SU-I-2	30	10.10.13	SU	I	o	2	0.0271	0.0097	0.0128	0.0239	0.0008	0.2112	2.7993
SU-I-3	30	10.10.13	SU	I	o	3	0.0331	0.0117	0.0155	0.0268	0.0008	0.2169	2.8200
SU-I-4	30	10.10.13	SU	I	o	4	0.0314	0.0082	0.0200	0.0335	0.0009	0.2731	3.8431
SU-II-1	30	10.10.13	SU	II	o	1	0.0390	0.0121	0.0161	0.0292	0.0010	0.2006	3.2278
SU-II-2	30	10.10.13	SU	II	o	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SU-II-3	30	10.10.13	SU	II	o	3	0.0256	0.0054	0.0131	0.0274	0.0006	0.2238	4.7261
SU-II-4	30	10.10.13	SU	II	o	4	0.0285	0.0098	0.0140	0.0254	0.0005	0.2204	2.9013
HA-C-1	30	10.10.13	HA	C	o	1	0.0208	0.0076	0.0100	0.0180	0.0006	0.2154	2.7480
HA-C-2	30	10.10.13	HA	C	o	2	0.0104	0.0045	0.0056	0.0252	0.0006	0.1391	2.2913
HA-C-3	30	10.10.13	HA	C	o	3	0.0041	0.0025	0.0025	0.0176	0.0003	0.1039	1.6579

HA-C-4	30	10.10.13	HA	C	o	4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
HA-I-1	30	10.10.13	HA	I	o	1	0.0142	0.0045	0.0073	0.0309	0.0007	0.1473	3.1246
HA-I-2	30	10.10.13	HA	I	o	2	0.0423	0.0160	0.0209	0.0395	0.0014	0.2138	2.6484
HA-I-3	30	10.10.13	HA	I	o	3	0.0202	0.0082	0.0114	0.0300	0.0010	0.1949	2.4726
HA-I-4	30	10.10.13	HA	I	o	4	0.0178	0.0069	0.0071	0.0156	0.0007	0.1770	2.5578
HA-II-1	30	10.10.13	HA	II	o	1	0.0121	0.0054	0.0075	0.0351	0.0009	0.1436	2.2368
HA-II-2	30	10.10.13	HA	II	o	2	0.0182	0.0068	0.0087	0.0345	0.0007	0.1467	2.6748
HA-II-3	30	10.10.13	HA	II	o	3	0.0269	0.0100	0.0127	0.0321	0.0010	0.1836	2.6961
HA-II-4	30	10.10.13	HA	II	o	4	0.0315	0.0109	0.0130	0.0287	0.0009	0.1831	2.8787
ST-C-1	86	12.12.13	ST	C	o	1	0.0257	0.0089	0.0045	0.0029	0.0000	0.1191	2.8922
ST-C-2	86	12.12.13	ST	C	o	2	0.0168	0.0067	0.0028	0.0027	0.0005	0.1075	2.5007
ST-C-3	86	12.12.13	ST	C	o	3	0.0138	0.0056	0.0024	0.0025	0.0000	0.1085	2.4714
ST-C-4	86	12.12.13	ST	C	o	4	0.0188	0.0082	0.0039	0.0027	0.0003	0.1314	2.3038
ST-I-1	86	12.12.13	ST	I	o	1	0.0230	0.0089	0.0040	0.0032	0.0000	0.1143	2.6011
ST-I-2	86	12.12.13	ST	I	o	2	0.0115	0.0045	0.0020	0.0027	0.0000	0.1047	2.5863
ST-I-3	86	12.12.13	ST	I	o	3	0.0195	0.0075	0.0015	0.0029	0.0000	0.0509	2.6123
ST-I-4	86	12.12.13	ST	I	o	4	0.0149	0.0080	0.0026	0.0025	0.0000	0.1026	1.8553
ST-II-1	86	12.12.13	ST	II	o	1	0.0167	0.0064	0.0018	0.0026	0.0010	0.0701	2.5977
ST-II-2	86	12.12.13	ST	II	o	2	0.0192	0.0073	0.0034	0.0027	0.0000	0.1161	2.6458
ST-II-3	86	12.12.13	ST	II	o	3	0.0168	0.0041	0.0030	0.0026	0.0007	0.1282	4.1298
ST-II-4	86	12.12.13	ST	II	o	4	0.0243	0.0091	0.0045	0.0029	0.0000	0.1227	2.6771
SU-C-1	86	12.12.13	SU	C	o	1	0.0150	0.0068	0.0018	0.0027	0.0000	0.0719	2.2151
SU-C-2	86	12.12.13	SU	C	o	2	0.0183	0.0086	0.0022	0.0026	0.0000	0.0763	2.1345
SU-C-3	86	12.12.13	SU	C	o	3	0.0232	0.0076	0.0029	0.0030	0.0000	0.0870	3.0668
SU-C-4	86	12.12.13	SU	C	o	4	0.0219	0.0076	0.0089	0.0018	0.0000	0.2835	2.8752
SU-I-1	86	12.12.13	SU	I	o	1	0.0285	0.0096	0.0085	0.0222	0.0007	0.1417	2.9699
SU-I-2	86	12.12.13	SU	I	o	2	0.0441	0.0140	0.0196	0.0279	0.0011	0.2284	3.1484
SU-I-3	86	12.12.13	SU	I	o	3	0.0269	0.0089	0.0108	0.0235	0.0008	0.1823	3.0380
SU-I-4	86	12.12.13	SU	I	o	4	0.0232	0.0077	0.0099	0.0219	0.0008	0.1880	3.0022
SU-II-1	86	12.12.13	SU	II	o	1	0.0275	0.0091	0.0108	0.0247	0.0008	0.1765	3.0179
SU-II-2	86	12.12.13	SU	II	o	2	0.0469	0.0140	0.0178	0.0303	0.0012	0.1956	3.3537
SU-II-3	86	12.12.13	SU	II	o	3	0.0202	0.0074	0.0093	0.0217	0.0006	0.1879	2.7297
SU-II-4	86	12.12.13	SU	II	o	4	0.0197	0.0061	0.0083	0.0232	0.0006	0.1706	3.2474
HA-C-1	86	12.12.13	HA	C	o	1	0.0092	0.0049	0.0042	0.0230	0.0007	0.1130	1.8963
HA-C-2	86	12.12.13	HA	C	o	2	0.0183	0.0072	0.0078	0.0227	0.0008	0.1615	2.5294
HA-C-3	86	12.12.13	HA	C	o	3	0.0177	0.0077	0.0075	0.0221	0.0009	0.1582	2.2883
Soil sample name	**Days after appli-cation**	**Date**	**Site**	**Treat-ment**	**Treated layer [0-7 cm]**	**Repli-cate**	**gram + [nmol g^{-1}]**	**gram - [nmol g^{-1}]**	**fungi [nmol g^{-1}]**	**unspecific bacteria [nmol g^{-1}]**	**protozoa [nmol g^{-1}]**	**fungi : bacteria**	**gram + : gram -**

HA-C-4	86	12.12.13	HA	C	o	4	0.0123	0.0059	0.0051	0.0240	0.0007	0.1203	2.0957
HA-I-1	86	12.12.13	HA	I	o	1	0.0198	0.0082	0.0084	0.0300	0.0008	0.1455	2.4321
HA-I-2	86	12.12.13	HA	I	o	2	0.0182	0.0074	0.0078	0.0236	0.0008	0.1587	2.4418
HA-I-3	86	12.12.13	HA	I	o	3	0.0171	0.0069	0.0071	0.0240	0.0007	0.1488	2.4660
HA-I-4	86	12.12.13	HA	I	o	4	0.0136	0.0059	0.0065	0.0236	0.0007	0.1501	2.2941
HA-II-1	86	12.12.13	HA	II	o	1	0.0184	0.0070	0.0079	0.0269	0.0008	0.1504	2.6341
HA-II-2	86	12.12.13	HA	II	o	2	0.0118	0.0051	0.0066	0.0257	0.0006	0.1554	2.2889
HA-II-3	86	12.12.13	HA	II	o	3	0.0128	0.0057	0.0066	0.0267	0.0007	0.1455	2.2701
HA-II-4	86	12.12.13	HA	II	o	4	0.0165	0.0048	0.0078	0.0281	0.0008	0.1579	3.4015

Soil sample name	**Days after appli-cation**	**Date**	**Site**	**Treat-ment**	**Unteated layer [7-14 cm]**	**Repli-cate**	**14:0 [nmol g^{-1}]**	**i 15:0 [nmol g^{-1}]**	**a 15:0 [nmol g^{-1}]**	**15:0 [nmol g^{-1}]**	**2-OH 12:0 [nmol g^{-1}]**	**i 16:0 [nmol g^{-1}]**	**i 17:0 [nmol g^{-1}]**	**17:0 [nmol g^{-1}]**	**cy 17:0 (9/10) [nmol g^{-1}]**	**18:0 [nmol g^{-1}]**	**18:1 (9) t [nmol g^{-1}]**	**18:1 (9) c [nmol g^{-1}]**	**18:2 (9,12) c [nmol g^{-1}]**	**19:0 [nmol g^{-1}]**	**cy 19:0 (9/10) [nmol g^{-1}]**	**20:0 [nmol g^{-1}]**
ST-C-1	2	19.09.13	ST	C	u	1	0.0029	0.0087	0.0061	0.0018	0.0003	0.0048	0.0021	0.0012	0.0034	0.0218	0.0002	0.0075	0.0023	0.0084	0.0005	0.0007
ST-C-2	2	19.09.13	ST	C	u	2	0.0028	0.0098	0.0066	0.0014	0.0004	0.0054	0.0031	0.0011	0.0035	0.0194	0.0001	0.0077	0.0026	0.0084	0.0005	0.0007
ST-C-3	2	19.09.13	ST	C	u	3	0.0061	0.0268	0.0182	0.0038	0.0008	0.0134	0.0081	0.0033	0.0100	0.0297	0.0002	0.0186	0.0054	0.0084	0.0000	0.0014
ST-C-4	2	19.09.13	ST	C	u	4	0.0043	0.0142	0.0098	0.0023	0.0000	0.0070	0.0000	0.0014	0.0061	0.0227	0.0002	0.0035	0.0031	0.0084	0.0005	0.0007
ST-I-1	2	19.09.13	ST	I	u	1	0.0033	0.0107	0.0072	0.0015	0.0000	0.0054	0.0024	0.0014	0.0043	0.0213	0.0002	0.0086	0.0027	0.0084	0.0005	0.0007
ST-I-2	2	19.09.13	ST	I	u	2	0.0031	0.0102	0.0068	0.0014	0.0004	0.0056	0.0026	0.0009	0.0040	0.0190	0.0002	0.0078	0.0025	0.0084	0.0005	0.0007
ST-I-3	2	19.09.13	ST	I	u	3	0.0032	0.0111	0.0072	0.0015	0.0004	0.0061	0.0029	0.0015	0.0043	0.0207	0.0002	0.0090	0.0027	0.0084	0.0005	0.0008
ST-I-4	2	19.09.13	ST	I	u	4	0.0035	0.0126	0.0085	0.0016	0.0004	0.0064	0.0033	0.0014	0.0052	0.0232	0.0002	0.0104	0.0030	0.0084	0.0006	0.0008
ST-II-1	2	19.09.13	ST	II	u	1	0.0111	0.0320	0.0223	0.0058	0.0014	0.0169	0.0082	0.0038	0.0124	0.0387	0.0003	0.0251	0.0097	0.0084	0.0000	0.0011
ST-II-2	2	19.09.13	ST	II	u	2	0.0038	0.0152	0.0101	0.0019	0.0006	0.0074	0.0040	0.0015	0.0057	0.0245	0.0002	0.0118	0.0033	0.0084	0.0007	0.0010
ST-II-3	2	19.09.13	ST	II	u	3	0.0068	0.0239	0.0156	0.0038	0.0008	0.0105	0.0000	0.0018	0.0017	0.0317	0.0002	0.0058	0.0056	0.0084	0.0000	0.0010
ST-II-4	2	19.09.13	ST	II	u	4	0.0039	0.0143	0.0093	0.0020	0.0005	0.0074	0.0036	0.0014	0.0055	0.0239	0.0002	0.0114	0.0035	0.0084	0.0007	0.0011
SU-C-1	2	19.09.13	SU	C	u	1	0.0021	0.0024	0.0013	0.0009	0.0004	0.0022	0.0007	0.0009	0.0008	0.0205	0.0001	0.0030	0.0009	0.0084	0.0000	0.0004
SU-C-2	2	19.09.13	SU	C	u	2	0.0046	0.0185	0.0117	0.0022	0.0007	0.0085	0.0047	0.0016	0.0058	0.0257	0.0003	0.0128	0.0035	0.0084	0.0005	0.0012
SU-C-3	2	19.09.13	SU	C	u	3	0.0035	0.0127	0.0078	0.0015	0.0001	0.0060	0.0033	0.0015	0.0041	0.0214	0.0002	0.0107	0.0032	0.0084	0.0004	0.0007
SU-C-4	2	19.09.13	SU	C	u	4	0.0109	0.0417	0.0235	0.0067	0.0011	0.0177	0.0105	0.0024	0.0119	0.0395	0.0003	0.0290	0.0066	0.0084	0.0000	0.0011
SU-I-1	2	19.09.13	SU	I	u	1	0.0022	0.0039	0.0023	0.0010	0.0002	0.0027	0.0010	0.0009	0.0011	0.0179	0.0001	0.0038	0.0013	0.0084	0.0000	0.0004
SU-I-2	2	19.09.13	SU	I	u	2	0.0044	0.0158	0.0092	0.0020	0.0004	0.0081	0.0041	0.0016	0.0049	0.0231	0.0003	0.0114	0.0047	0.0084	0.0006	0.0010
SU-I-3	2	19.09.13	SU	I	u	3	0.0036	0.0135	0.0079	0.0017	0.0014	0.0064	0.0034	0.0012	0.0041	0.0195	0.0003	0.0092	0.0035	0.0084	0.0004	0.0008
SU-I-4	2	19.09.13	SU	I	u	4	0.0033	0.0074	0.0040	0.0013	0.0002	0.0039	0.0016	0.0009	0.0022	0.0227	0.0002	0.0058	0.0013	0.0084	0.0000	0.0007
SU-II-1	2	19.09.13	SU	II	u	1	0.0027	0.0066	0.0039	0.0011	0.0002	0.0037	0.0018	0.0011	0.0023	0.0243	0.0002	0.0000	0.0019	0.0084	0.0003	0.0005
SU-II-2	2	19.09.13	SU	II	u	2	0.0038	0.0137	0.0082	0.0018	0.0004	0.0068	0.0035	0.0014	0.0041	0.0221	0.0003	0.0102	0.0028	0.0084	0.0006	0.0009
SU-II-3	2	19.09.13	SU	II	u	3	0.0055	0.0178	0.0102	0.0029	0.0005	0.0075	0.0000	0.0017	0.0045	0.0284	0.0002	0.0023	0.0029	0.0084	0.0000	0.0008
Soil sample name	**Days after appli-cation**	**Date**	**Site**	**Treat-ment**	**Unteated layer [7-14 cm]**	**Repli-cate**	**14:0 [nmol g^{-1}]**	**i 15:0 [nmol g^{-1}]**	**a 15:0 [nmol g^{-1}]**	**15:0 [nmol g^{-1}]**	**2-OH 12:0 [nmol g^{-1}]**	**i 16:0 [nmol g^{-1}]**	**i 17:0 [nmol g^{-1}]**	**17:0 [nmol g^{-1}]**	**cy 17:0 (9/10) [nmol g^{-1}]**	**18:0 [nmol g^{-1}]**	**18:1 (9) t [nmol g^{-1}]**	**18:1 (9) c [nmol g^{-1}]**	**18:2 (9,12) c [nmol g^{-1}]**	**19:0 [nmol g^{-1}]**	**cy 19:0 (9/10) [nmol g^{-1}]**	**20:0 [nmol g^{-1}]**

SU-II-4	2	19.09.13	SU	II	u	4	0.0071	0.0213	0.0130	0.0038	0.0008	0.0091	0.0000	0.0024	0.0009	0.0290	0.0001	0.0028	0.0052	0.0084	0.0000	0.0008
HA-C-1	2	19.09.13	HA	C	u	1	0.0051	0.0141	0.0082	0.0025	0.0004	0.0059	0.0000	0.0014	0.0010	0.0268	0.0001	0.0032	0.0025	0.0084	0.0000	0.0008
HA-C-2	2	19.09.13	HA	C	u	2	0.0053	0.0142	0.0082	0.0025	0.0004	0.0060	0.0000	0.0012	0.0009	0.0258	0.0001	0.0032	0.0027	0.0084	0.0000	0.0008
HA-C-3	2	19.09.13	HA	C	u	3	0.0032	0.0085	0.0050	0.0013	0.0001	0.0045	0.0019	0.0010	0.0027	0.0204	0.0001	0.0062	0.0018	0.0084	0.0003	0.0008
HA-C-4	2	19.09.13	HA	C	u	4	0.0024	0.0052	0.0030	0.0009	0.0001	0.0031	0.0012	0.0011	0.0015	0.0189	0.0001	0.0040	0.0009	0.0084	0.0001	0.0006
HA-I-1	2	19.09.13	HA	I	u	1	0.0050	0.0118	0.0069	0.0023	0.0002	0.0052	0.0000	0.0013	0.0007	0.0260	0.0002	0.0024	0.0024	0.0084	0.0000	0.0008
HA-I-2	2	19.09.13	HA	I	u	2	0.0091	0.0295	0.0161	0.0044	0.0008	0.0105	0.0058	0.0022	0.0080	0.0384	0.0003	0.0162	0.0043	0.0084	0.0000	0.0012
HA-I-3	2	19.09.13	HA	I	u	3	0.0075	0.0184	0.0115	0.0039	0.0003	0.0075	0.0044	0.0015	0.0061	0.0180	0.0001	0.0128	0.0025	0.0084	0.0009	0.0010
HA-I-4	2	19.09.13	HA	I	u	4	0.0021	0.0027	0.0017	0.0007	0.0002	0.0019	0.0007	0.0008	0.0010	0.0299	0.0002	0.0043	0.0012	0.0084	0.0001	0.0000
HA-II-1	2	19.09.13	HA	II	u	1	0.0028	0.0059	0.0038	0.0011	0.0002	0.0035	0.0014	0.0010	0.0019	0.0254	0.0002	0.0052	0.0014	0.0084	0.0002	0.0007
HA-II-2	2	19.09.13	HA	II	u	2	0.0034	0.0087	0.0052	0.0013	0.0002	0.0043	0.0019	0.0011	0.0026	0.0253	0.0002	0.0066	0.0021	0.0084	0.0003	0.0008
HA-II-3	2	19.09.13	HA	II	u	3	0.0027	0.0064	0.0036	0.0010	0.0001	0.0034	0.0014	0.0010	0.0024	0.0208	0.0002	0.0053	0.0019	0.0084	0.0002	0.0007
HA-II-4	2	19.09.13	HA	II	u	4	0.0029	0.0066	0.0037	0.0011	0.0002	0.0035	0.0015	0.0011	0.0020	0.0211	0.0001	0.0052	0.0013	0.0084	0.0002	0.0007
ST-C-1	30	10.10.13	ST	C	u	1	0.0080	0.0265	0.0194	0.0035	0.0008	0.0131	0.0064	0.0030	0.0098	0.0276	0.0003	0.0181	0.0043	0.0084	0.0000	0.0013
ST-C-2	30	10.10.13	ST	C	u	2	0.0042	0.0167	0.0109	0.0022	0.0004	0.0084	0.0041	0.0018	0.0060	0.0262	0.0002	0.0117	0.0031	0.0084	0.0000	0.0009
ST-C-3	30	10.10.13	ST	C	u	3	0.0053	0.0216	0.0150	0.0033	0.0007	0.0107	0.0057	0.0024	0.0078	0.0286	0.0002	0.0160	0.0042	0.0084	0.0000	0.0012
ST-C-4	30	10.10.13	ST	C	u	4	0.0085	0.0329	0.0230	0.0039	0.0005	0.0151	0.0085	0.0030	0.0124	0.0326	0.0004	0.0235	0.0059	0.0084	0.0000	0.0014
ST-I-1	30	10.10.13	ST	I	u	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ST-I-2	30	10.10.13	ST	I	u	2	0.0075	0.0367	0.0250	0.0045	0.0010	0.0166	0.0092	0.0033	0.0134	0.0319	0.0000	0.0258	0.0082	0.0084	0.0000	0.0015
ST-I-3	30	10.10.13	ST	I	u	3	0.0057	0.0253	0.0183	0.0031	0.0011	0.0130	0.0064	0.0026	0.0095	0.0312	0.0003	0.0191	0.0059	0.0084	0.0000	0.0012
ST-I-4	30	10.10.13	ST	I	u	4	0.0060	0.0235	0.0162	0.0032	0.0007	0.0111	0.0059	0.0025	0.0089	0.0368	0.0002	0.0183	0.0050	0.0084	0.0000	0.0012
ST-II-1	30	10.10.13	ST	II	u	1	0.0047	0.0201	0.0143	0.0025	0.0009	0.0099	0.0049	0.0020	0.0079	0.0229	0.0003	0.0146	0.0033	0.0084	0.0000	0.0009
ST-II-2	30	10.10.13	ST	II	u	2	0.0052	0.0218	0.0151	0.0028	0.0009	0.0109	0.0054	0.0025	0.0079	0.0335	0.0002	0.0169	0.0056	0.0084	0.0000	0.0013
ST-II-3	30	10.10.13	ST	II	u	3	0.0049	0.0236	0.0158	0.0031	0.0006	0.0117	0.0064	0.0024	0.0084	0.0289	0.0004	0.0161	0.0050	0.0084	0.0000	0.0009
ST-II-4	30	10.10.13	ST	II	u	4	0.0059	0.0262	0.0170	0.0034	0.0005	0.0126	0.0074	0.0027	0.0099	0.0318	0.0004	0.0183	0.0050	0.0084	0.0000	0.0012
SU-C-1	30	10.10.13	SU	C	u	1	0.0052	0.0198	0.0127	0.0029	0.0007	0.0095	0.0051	0.0023	0.0064	0.0326	0.0003	0.0150	0.0037	0.0084	0.0000	0.0010
SU-C-2	30	10.10.13	SU	C	u	2	0.0036	0.0126	0.0075	0.0020	0.0005	0.0063	0.0040	0.0015	0.0039	0.0223	0.0002	0.0106	0.0019	0.0084	0.0000	0.0008
SU-C-3	30	10.10.13	SU	C	u	3	0.0059	0.0228	0.0147	0.0034	0.0006	0.0104	0.0059	0.0039	0.0073	0.0317	0.0002	0.0154	0.0035	0.0084	0.0000	0.0012
SU-C-4	30	10.10.13	SU	C	u	4	0.0033	0.0092	0.0054	0.0016	0.0001	0.0047	0.0028	0.0014	0.0027	0.0223	0.0001	0.0061	0.0014	0.0084	0.0000	0.0007
SU-I-1	30	10.10.13	SU	I	u	1	0.0054	0.0175	0.0111	0.0030	0.0008	0.0080	0.0042	0.0021	0.0055	0.0266	0.0002	0.0126	0.0037	0.0084	0.0000	0.0008
SU-I-2	30	10.10.13	SU	I	u	2	0.0070	0.0315	0.0190	0.0041	0.0011	0.0140	0.0079	0.0030	0.0096	0.0333	0.0004	0.0211	0.0066	0.0084	0.0000	0.0014
SU-I-3	30	10.10.13	SU	I	u	3	0.0077	0.0273	0.0171	0.0040	0.0014	0.0122	0.0071	0.0026	0.0097	0.0335	0.0003	0.0186	0.0042	0.0084	0.0000	0.0011
SU-I-4	30	10.10.13	SU	I	u	4	0.0072	0.0303	0.0193	0.0042	0.0010	0.0135	0.0090	0.0030	0.0094	0.0303	0.0003	0.0206	0.0045	0.0084	0.0000	0.0013
SU-II-1	30	10.10.13	SU	II	u	1	0.0063	0.0280	0.0174	0.0033	0.0009	0.0121	0.0070	0.0025	0.0090	0.0308	0.0002	0.0202	0.0052	0.0084	0.0000	0.0010
SU-II-2	30	10.10.13	SU	II	u	2	0.0042	0.0159	0.0096	0.0023	0.0003	0.0075	0.0039	0.0017	0.0067	0.0247	0.0002	0.0131	0.0024	0.0084	0.0000	0.0008
SU-II-3	30	10.10.13	SU	II	u	3	0.0059	0.0241	0.0141	0.0029	0.0011	0.0114	0.0061	0.0024	0.0105	0.0262	0.0002	0.0157	0.0041	0.0084	0.0000	0.0011
Soil sample name	**Days after appli-cation**	**Date**	**Site**	**Treat-ment**	**Unteated layer [7-14 cm]**	**Repli-cate**	**14:0 [nmol g^{-1}]**	**i 15:0 [nmol g^{-1}]**	**a 15:0 [nmol g^{-1}]**	**15:0 [nmol g^{-1}]**	**2-OH 12:0 [nmol g^{-1}]**	**i 16:0 [nmol g^{-1}]**	**i 17:0 [nmol g^{-1}]**	**17:0 [nmol g^{-1}]**	**cy 17:0 (9/10) [nmol g^{-1}]**	**18:0 [nmol g^{-1}]**	**18:1 (9) t [nmol g^{-1}]**	**18:1 (9) c [nmol g^{-1}]**	**18:2 (9,12) c [nmol g^{-1}]**	**19:0 [nmol g^{-1}]**	**cy 19:0 (9/10) [nmol g^{-1}]**	**20:0 [nmol g^{-1}]**

SU-II-4	30	10.10.13	SU	II	u	4	0.0064	0.0265	0.0166	0.0032	0.0007	0.0124	0.0080	0.0026	0.0079	0.0343	0.0004	0.0182	0.0040	0.0084	0.0000	0.0013
HA-C-1	30	10.10.13	HA	C	u	1	0.0032	0.0077	0.0044	0.0013	0.0003	0.0041	0.0025	0.0011	0.0023	0.0213	0.0001	0.0059	0.0016	0.0084	0.0000	0.0007
HA-C-2	30	10.10.13	HA	C	u	2	0.0037	0.0094	0.0058	0.0015	0.0005	0.0049	0.0021	0.0011	0.0030	0.0243	0.0002	0.0071	0.0017	0.0084	0.0000	0.0008
HA-C-3	30	10.10.13	HA	C	u	3	0.0056	0.0167	0.0102	0.0023	0.0004	0.0080	0.0033	0.0016	0.0045	0.0324	0.0002	0.0116	0.0028	0.0084	0.0000	0.0014
HA-C-4	30	10.10.13	HA	C	u	4	0.0039	0.0105	0.0062	0.0015	0.0003	0.0053	0.0030	0.0013	0.0034	0.0242	0.0003	0.0078	0.0031	0.0084	0.0000	0.0007
HA-I-1	30	10.10.13	HA	I	u	1	0.0028	0.0053	0.0029	0.0012	0.0002	0.0030	0.0012	0.0010	0.0013	0.0197	0.0002	0.0042	0.0010	0.0084	0.0004	0.0006
HA-I-2	30	10.10.13	HA	I	u	2	0.0068	0.0312	0.0199	0.0036	0.0011	0.0135	0.0080	0.0026	0.0103	0.0263	0.0003	0.0216	0.0048	0.0084	0.0000	0.0010
HA-I-3	30	10.10.13	HA	I	u	3	0.0048	0.0147	0.0093	0.0020	0.0003	0.0071	0.0033	0.0023	0.0044	0.0287	0.0001	0.0124	0.0020	0.0084	0.0000	0.0012
HA-I-4	30	10.10.13	HA	I	u	4	0.0035	0.0096	0.0056	0.0014	0.0003	0.0048	0.0021	0.0013	0.0030	0.0243	0.0001	0.0069	0.0017	0.0084	0.0000	0.0007
HA-II-1	30	10.10.13	HA	II	u	1	0.0055	0.0181	0.0116	0.0027	0.0006	0.0085	0.0041	0.0030	0.0060	0.0276	0.0001	0.0110	0.0026	0.0084	0.0000	0.0011
HA-II-2	30	10.10.13	HA	II	u	2	0.0047	0.0120	0.0067	0.0019	0.0004	0.0062	0.0029	0.0016	0.0037	0.0364	0.0002	0.0099	0.0030	0.0084	0.0000	0.0009
HA-II-3	30	10.10.13	HA	II	u	3	0.0041	0.0130	0.0075	0.0019	0.0000	0.0066	0.0029	0.0013	0.0040	0.0226	0.0000	0.0086	0.0021	0.0084	0.0000	0.0009
HA-II-4	30	10.10.13	HA	II	u	4	0.0039	0.0105	0.0062	0.0015	0.0004	0.0057	0.0024	0.0016	0.0033	0.0270	0.0002	0.0081	0.0021	0.0084	0.0000	0.0008
ST-C-1	86	12.12.13	ST	C	u	1	0.0042	0.0184	0.0132	0.0025	0.0008	0.0084	0.0044	0.0020	0.0072	0.0209	0.0002	0.0139	0.0000	0.0084	0.0000	0.0009
ST-C-2	86	12.12.13	ST	C	u	2	0.0068	0.0323	0.0231	0.0045	0.0011	0.0152	0.0080	0.0034	0.0124	0.0293	0.0004	0.0224	0.0056	0.0084	0.0000	0.0010
ST-C-3	86	12.12.13	ST	C	u	3	0.0033	0.0131	0.0093	0.0022	0.0005	0.0064	0.0032	0.0017	0.0050	0.0201	0.0001	0.0107	0.0028	0.0084	0.0000	0.0007
ST-C-4	86	12.12.13	ST	C	u	4	0.0057	0.0197	0.0145	0.0034	0.0010	0.0091	0.0051	0.0025	0.0075	0.0229	0.0002	0.0139	0.0030	0.0084	0.0000	0.0008
ST-I-1	86	12.12.13	ST	I	u	1	0.0062	0.0271	0.0192	0.0035	0.0009	0.0126	0.0066	0.0033	0.0107	0.0267	0.0000	0.0200	0.0047	0.0084	0.0000	0.0011
ST-I-2	86	12.12.13	ST	I	u	2	0.0086	0.0330	0.0237	0.0047	0.0012	0.0193	0.0083	0.0036	0.0132	0.0332	0.0005	0.0249	0.0069	0.0084	0.0000	0.0012
ST-I-3	86	12.12.13	ST	I	u	3	0.0093	0.0324	0.0210	0.0052	0.0010	0.0139	0.0081	0.0034	0.0118	0.0423	0.0004	0.0257	0.0065	0.0084	0.0000	0.0013
ST-I-4	86	12.12.13	ST	I	u	4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ST-II-1	86	12.12.13	ST	II	u	1	0.0107	0.0430	0.0279	0.0059	0.0013	0.0174	0.0094	0.0036	0.0155	0.0429	0.0004	0.0293	0.0080	0.0084	0.0000	0.0013
ST-II-2	86	12.12.13	ST	II	u	2	0.0039	0.0136	0.0099	0.0021	0.0005	0.0067	0.0035	0.0020	0.0050	0.0220	0.0002	0.0101	0.0026	0.0084	0.0000	0.0008
ST-II-3	86	12.12.13	ST	II	u	3	0.0052	0.0178	0.0123	0.0026	0.0005	0.0083	0.0043	0.0022	0.0064	0.0256	0.0002	0.0124	0.0033	0.0084	0.0000	0.0010
ST-II-4	86	12.12.13	ST	II	u	4	0.0055	0.0168	0.0110	0.0028	0.0005	0.0073	0.0000	0.0016	0.0055	0.0286	0.0002	0.0038	0.0037	0.0084	0.0000	0.0007
SU-C-1	86	12.12.13	SU	C	u	1	0.0048	0.0169	0.0103	0.0025	0.0000	0.0071	0.0000	0.0015	0.0056	0.0234	0.0001	0.0024	0.0029	0.0084	0.0000	0.0007
SU-C-2	86	12.12.13	SU	C	u	2	0.0071	0.0119	0.0082	0.0036	0.0000	0.0057	0.0033	0.0019	0.0039	0.0243	0.0000	0.0108	0.0026	0.0084	0.0000	0.0013
SU-C-3	86	12.12.13	SU	C	u	3	0.0051	0.0195	0.0120	0.0030	0.0004	0.0086	0.0049	0.0023	0.0061	0.0274	0.0002	0.0128	0.0035	0.0084	0.0000	0.0010
SU-C-4	86	12.12.13	SU	C	u	4	0.0060	0.0182	0.0125	0.0029	0.0007	0.0081	0.0044	0.0018	0.0058	0.0226	0.0002	0.0120	0.0004	0.0084	0.0000	0.0009
SU-I-1	86	12.12.13	SU	I	u	1	0.0087	0.0229	0.0142	0.0044	0.0013	0.0102	0.0053	0.0020	0.0068	0.0382	0.0000	0.0032	0.0048	0.0084	0.0000	0.0009
SU-I-2	86	12.12.13	SU	I	u	2	0.0043	0.0144	0.0093	0.0025	0.0006	0.0069	0.0037	0.0024	0.0043	0.0222	0.0002	0.0107	0.0024	0.0084	0.0000	0.0008
SU-I-3	86	12.12.13	SU	I	u	3	0.0078	0.0340	0.0211	0.0041	0.0012	0.0142	0.0085	0.0028	0.0108	0.0280	0.0003	0.0234	0.0050	0.0084	0.0000	0.0009
SU-I-4	86	12.12.13	SU	I	u	4	0.0070	0.0163	0.0094	0.0036	0.0005	0.0093	0.0036	0.0020	0.0041	0.0317	0.0002	0.0022	0.0034	0.0084	0.0000	0.0008
SU-II-1	86	12.12.13	SU	II	u	1	0.0059	0.0191	0.0117	0.0031	0.0007	0.0082	0.0000	0.0017	0.0062	0.0247	0.0002	0.0030	0.0031	0.0084	0.0007	0.0008
SU-II-2	86	12.12.13	SU	II	u	2	0.0062	0.0168	0.0099	0.0033	0.0005	0.0071	0.0000	0.0023	0.0043	0.0301	0.0002	0.0020	0.0022	0.0084	0.0000	0.0008
SU-II-3	86	12.12.13	SU	II	u	3	0.0066	0.0225	0.0138	0.0035	0.0007	0.0096	0.0000	0.0018	0.0064	0.0296	0.0003	0.0031	0.0045	0.0084	0.0000	0.0008
Soil sample name	**Days after appli-cation**	**Date**	**Site**	**Treat-ment**	**Unteated layer [7-14 cm]**	**Repli-cate**	**14:0 [nmol g^{-1}]**	**i 15:0 [nmol g^{-1}]**	**a 15:0 [nmol g^{-1}]**	**15:0 [nmol g^{-1}]**	**2-OH 12:0 [nmol g^{-1}]**	**i 16:0 [nmol g^{-1}]**	**i 17:0 [nmol g^{-1}]**	**17:0 [nmol g^{-1}]**	**cy 17:0 (9/10) [nmol g^{-1}]**	**18:0 [nmol g^{-1}]**	**18:1 (9) t [nmol g^{-1}]**	**18:1 (9) c [nmol g^{-1}]**	**18:2 (9,12) c [nmol g^{-1}]**	**19:0 [nmol g^{-1}]**	**cy 19:0 (9/10) [nmol g^{-1}]**	**20:0 [nmol g^{-1}]**

SU-II-4	86	12.12.13	SU	II	u	4	0.0059	0.0219	0.0132	0.0030	0.0000	0.0097	0.0000	0.0014	0.0010	0.0280	0.0002	0.0029	0.0041	0.0084	0.0000	0.0009
HA-C-1	86	12.12.13	HA	C	u	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
HA-C-2	86	12.12.13	HA	C	u	2	0.0073	0.0174	0.0108	0.0033	0.0008	0.0072	0.0036	0.0021	0.0050	0.0278	0.0002	0.0042	0.0024	0.0084	0.0000	0.0010
HA-C-3	86	12.12.13	HA	C	u	3	0.0033	0.0092	0.0057	0.0014	0.0004	0.0045	0.0021	0.0012	0.0027	0.0204	0.0001	0.0023	0.0014	0.0084	0.0000	0.0008
HA-C-4	86	12.12.13	HA	C	u	4	0.0052	0.0128	0.0072	0.0024	0.0004	0.0055	0.0000	0.0040	0.0028	0.0283	0.0001	0.0029	0.0023	0.0084	0.0000	0.0008
HA-I-1	86	12.12.13	HA	I	u	1	0.0042	0.0139	0.0091	0.0017	0.0006	0.0064	0.0030	0.0016	0.0045	0.0206	0.0002	0.0033	0.0016	0.0084	0.0000	0.0008
HA-I-2	86	12.12.13	HA	I	u	2	0.0058	0.0212	0.0135	0.0036	0.0007	0.0095	0.0046	0.0067	0.0093	0.0237	0.0003	0.0171	0.0026	0.0084	0.0000	0.0008
HA-I-3	86	12.12.13	HA	I	u	3	0.0040	0.0066	0.0043	0.0018	0.0005	0.0032	0.0014	0.0010	0.0017	0.0210	0.0002	0.0014	0.0011	0.0084	0.0000	0.0007
HA-I-4	86	12.12.13	HA	I	u	4	0.0036	0.0080	0.0045	0.0016	0.0003	0.0037	0.0000	0.0012	0.0005	0.0221	0.0001	0.0017	0.0015	0.0084	0.0000	0.0007
HA-II-1	86	12.12.13	HA	II	u	1	0.0056	0.0133	0.0087	0.0033	0.0015	0.0062	0.0029	0.0102	0.0043	0.0242	0.0002	0.0081	0.0017	0.0084	0.0000	0.0008
HA-II-2	86	12.12.13	HA	II	u	2	0.0109	0.0357	0.0202	0.0058	0.0010	0.0142	0.0070	0.0046	0.0105	0.0397	0.0004	0.0202	0.0052	0.0084	0.0000	0.0010
HA-II-3	86	12.12.13	HA	II	u	3	0.0040	0.0095	0.0057	0.0018	0.0002	0.0041	0.0000	0.0016	0.0029	0.0223	0.0001	0.0020	0.0016	0.0084	0.0000	0.0007
HA-II-4	86	12.12.13	HA	II	u	4	0.0092	0.0154	0.0105	0.0042	0.0007	0.0067	0.0035	0.0024		0.0305	0.0002	0.0117	0.0030	0.0084	0.0000	0.0008

Soil sample name	**Days after appli-cation**	**Date**	**Site**	**Treat-ment**	**Unteated layer [7-14 cm]**	**Repli-cate**	**gram + [nmol g^{-1}]**	**gram - [nmol g^{-1}]**	**fungi [nmol g^{-1}]**	**unspecific bacteria [nmol g^{-1}]**	**protozoa [nmol g^{-1}]**	**fungi : bacteria**	**gram + : gram -**
ST-C-1	2	19.09.13	ST	C	u	1	0.0218	0.0080	0.0100	0.0239	0.0007	0.1861	2.7078
ST-C-2	2	19.09.13	ST	C	u	2	0.0249	0.0079	0.0104	0.0213	0.0007	0.1927	3.1332
ST-C-3	2	19.09.13	ST	C	u	3	0.0665	0.0194	0.0243	0.0343	0.0014	0.2019	3.4264
ST-C-4	2	19.09.13	ST	C	u	4	0.0310	0.0124	0.0068	0.0250	0.0007	0.0992	2.5034
ST-I-1	2	19.09.13	ST	I	u	1	0.0258	0.0095	0.0115	0.0227	0.0007	0.1980	2.7175
ST-I-2	2	19.09.13	ST	I	u	2	0.0251	0.0085	0.0105	0.0207	0.0007	0.1928	2.9692
ST-I-3	2	19.09.13	ST	I	u	3	0.0273	0.0096	0.0118	0.0226	0.0008	0.1992	2.8417
ST-I-4	2	19.09.13	ST	I	u	4	0.0308	0.0106	0.0136	0.0252	0.0008	0.2042	2.8939
ST-II-1	2	19.09.13	ST	II	u	1	0.0793	0.0273	0.0351	0.0460	0.0011	0.2301	2.9052
ST-II-2	2	19.09.13	ST	II	u	2	0.0366	0.0117	0.0153	0.0269	0.0010	0.2031	3.1213
ST-II-3	2	19.09.13	ST	II	u	3	0.0500	0.0103	0.0116	0.0363	0.0010	0.1196	4.8730
ST-II-4	2	19.09.13	ST	II	u	4	0.0346	0.0114	0.0152	0.0263	0.0011	0.2097	3.0294
SU-C-1	2	19.09.13	SU	C	u	1	0.0066	0.0038	0.0039	0.0218	0.0004	0.1216	1.7511
SU-C-2	2	19.09.13	SU	C	u	2	0.0434	0.0125	0.0165	0.0286	0.0012	0.1955	3.4595
SU-C-3	2	19.09.13	SU	C	u	3	0.0298	0.0095	0.0141	0.0230	0.0007	0.2254	3.1343
SU-C-4	2	19.09.13	SU	C	u	4	0.0935	0.0252	0.0359	0.0473	0.0011	0.2165	3.7083
SU-I-1	2	19.09.13	SU	I	u	1	0.0098	0.0042	0.0051	0.0191	0.0004	0.1548	2.3143
SU-I-2	2	19.09.13	SU	I	u	2	0.0372	0.0115	0.0163	0.0256	0.0010	0.2197	3.2304
SU-I-3	2	19.09.13	SU	I	u	3	0.0313	0.0093	0.0130	0.0226	0.0008	0.2055	3.3701
Soil sample name	**Days after appli-cation**	**Date**	**Site**	**Treat-ment**	**Unteated layer [7-14 cm]**	**Repli-cate**	**gram + [nmol g^{-1}]**	**gram - [nmol g^{-1}]**	**fungi [nmol g^{-1}]**	**unspecific bacteria [nmol g^{-1}]**	**protozoa [nmol g^{-1}]**	**fungi : bacteria**	**gram + : gram -**

SU-I-4	2	19.09.13	SU	I	u	4	0.0169	0.0065	0.0073	0.0241	0.0007	0.1529	2.6134
SU-II-1	2	19.09.13	SU	II	u	1	0.0160	0.0063	0.0021	0.0257	0.0005	0.0429	2.5262
SU-II-2	2	19.09.13	SU	II	u	2	0.0322	0.0098	0.0133	0.0243	0.0009	0.2016	3.2750
SU-II-3	2	19.09.13	SU	II	u	3	0.0354	0.0117	0.0055	0.0319	0.0008	0.0691	3.0383
SU-II-4	2	19.09.13	SU	II	u	4	0.0434	0.0104	0.0082	0.0336	0.0008	0.0935	4.1770
HA-C-1	2	19.09.13	HA	C	u	1	0.0282	0.0075	0.0059	0.0297	0.0008	0.0899	3.7657
HA-C-2	2	19.09.13	HA	C	u	2	0.0284	0.0075	0.0060	0.0286	0.0008	0.0937	3.7880
HA-C-3	2	19.09.13	HA	C	u	3	0.0200	0.0072	0.0082	0.0217	0.0008	0.1668	2.7726
HA-C-4	2	19.09.13	HA	C	u	4	0.0124	0.0051	0.0050	0.0199	0.0006	0.1337	2.4252
HA-I-1	2	19.09.13	HA	I	u	1	0.0239	0.0071	0.0049	0.0285	0.0008	0.0826	3.3773
HA-I-2	2	19.09.13	HA	I	u	2	0.0618	0.0193	0.0208	0.0436	0.0012	0.1665	3.2025
HA-I-3	2	19.09.13	HA	I	u	3	0.0418	0.0160	0.0154	0.0222	0.0010	0.1927	2.6062
HA-I-4	2	19.09.13	HA	I	u	4	0.0069	0.0040	0.0057	0.0308	0.0000	0.1362	1.7098
HA-II-1	2	19.09.13	HA	II	u	1	0.0146	0.0058	0.0067	0.0268	0.0007	0.1431	2.4908
HA-II-2	2	19.09.13	HA	II	u	2	0.0201	0.0074	0.0089	0.0269	0.0008	0.1641	2.7276
HA-II-3	2	19.09.13	HA	II	u	3	0.0150	0.0063	0.0073	0.0219	0.0007	0.1692	2.3749
HA-II-4	2	19.09.13	HA	II	u	4	0.0154	0.0061	0.0066	0.0224	0.0007	0.1495	2.5115
ST-C-1	30	10.10.13	ST	C	u	1	0.0654	0.0208	0.0227	0.0320	0.0013	0.1922	3.1524
ST-C-2	30	10.10.13	ST	C	u	2	0.0400	0.0120	0.0150	0.0289	0.0009	0.1854	3.3254
ST-C-3	30	10.10.13	ST	C	u	3	0.0530	0.0155	0.0204	0.0326	0.0012	0.2019	3.4221
ST-C-4	30	10.10.13	ST	C	u	4	0.0795	0.0239	0.0298	0.0370	0.0014	0.2125	3.3255
ST-I-1	30	10.10.13	ST	I	u	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ST-I-2	30	10.10.13	ST	I	u	2	0.0874	0.0242	0.0340	0.0374	0.0015	0.2281	3.6166
ST-I-3	30	10.10.13	ST	I	u	3	0.0630	0.0178	0.0253	0.0354	0.0012	0.2181	3.5449
ST-I-4	30	10.10.13	ST	I	u	4	0.0567	0.0174	0.0235	0.0408	0.0012	0.2047	3.2638
ST-II-1	30	10.10.13	ST	II	u	1	0.0491	0.0147	0.0181	0.0262	0.0009	0.2013	3.3538
ST-II-2	30	10.10.13	ST	II	u	2	0.0532	0.0156	0.0227	0.0373	0.0013	0.2142	3.4098
ST-II-3	30	10.10.13	ST	II	u	3	0.0575	0.0157	0.0215	0.0326	0.0009	0.2035	3.6555
ST-II-4	30	10.10.13	ST	II	u	4	0.0633	0.0185	0.0237	0.0357	0.0012	0.2017	3.4217
SU-C-1	30	10.10.13	SU	C	u	1	0.0471	0.0139	0.0191	0.0362	0.0010	0.1962	3.3795
SU-C-2	30	10.10.13	SU	C	u	2	0.0304	0.0090	0.0126	0.0248	0.0008	0.1967	3.3664
SU-C-3	30	10.10.13	SU	C	u	3	0.0537	0.0171	0.0191	0.0356	0.0012	0.1795	3.1394
SU-C-4	30	10.10.13	SU	C	u	4	0.0221	0.0075	0.0076	0.0240	0.0007	0.1424	2.9662
SU-I-1	30	10.10.13	SU	I	u	1	0.0407	0.0130	0.0165	0.0304	0.0008	0.1956	3.1410
SU-I-2	30	10.10.13	SU	I	u	2	0.0724	0.0196	0.0282	0.0385	0.0014	0.2158	3.6999
SU-I-3	30	10.10.13	SU	I	u	3	0.0637	0.0200	0.0230	0.0389	0.0011	0.1879	3.1866
Soil sample name	**Days after appli-cation**	**Date**	**Site**	**Treat-ment**	**Unteated layer [7-14 cm]**	**Repli-cate**	**gram + [nmol g^{-1}]**	**gram - [nmol g^{-1}]**	**fungi [nmol g^{-1}]**	**unspecific bacteria [nmol g^{-1}]**	**protozoa [nmol g^{-1}]**	**fungi : bacteria**	**gram + : gram -**

Soil sample name	Days after appli-cation	Date	Site	Treat-ment	Unteated layer [7-14 cm]	Repli-cate	gram + [nmol g^{-1}]	gram - [nmol g^{-1}]	fungi [nmol g^{-1}]	unspecific bacteria [nmol g^{-1}]	protozoa [nmol g^{-1}]	fungi : bacteria	gram + : gram -
SU-I-4	30	10.10.13	SU	I	u	4	0.0722	0.0197	0.0254	0.0355	0.0013	0.1993	3.6718
SU-II-1	30	10.10.13	SU	II	u	1	0.0645	0.0178	0.0256	0.0350	0.0010	0.2183	3.6350
SU-II-2	30	10.10.13	SU	II	u	2	0.0368	0.0125	0.0157	0.0274	0.0008	0.2042	2.9354
SU-II-3	30	10.10.13	SU	II	u	3	0.0557	0.0188	0.0200	0.0303	0.0011	0.1906	2.9640
SU-II-4	30	10.10.13	SU	II	u	4	0.0635	0.0168	0.0226	0.0382	0.0013	0.1904	3.7687
HA-C-1	30	10.10.13	HA	C	u	1	0.0187	0.0065	0.0076	0.0229	0.0007	0.1584	2.8746
HA-C-2	30	10.10.13	HA	C	u	2	0.0222	0.0077	0.0089	0.0263	0.0008	0.1590	2.8829
HA-C-3	30	10.10.13	HA	C	u	3	0.0382	0.0118	0.0145	0.0351	0.0014	0.1708	3.2472
HA-C-4	30	10.10.13	HA	C	u	4	0.0250	0.0086	0.0112	0.0259	0.0007	0.1877	2.8958
HA-I-1	30	10.10.13	HA	I	u	1	0.0124	0.0055	0.0054	0.0211	0.0006	0.1387	2.2506
HA-I-2	30	10.10.13	HA	I	u	2	0.0726	0.0197	0.0267	0.0310	0.0010	0.2167	3.6878
HA-I-3	30	10.10.13	HA	I	u	3	0.0344	0.0114	0.0146	0.0311	0.0012	0.1898	3.0027
HA-I-4	30	10.10.13	HA	I	u	4	0.0221	0.0077	0.0088	0.0261	0.0007	0.1569	2.8572
HA-II-1	30	10.10.13	HA	II	u	1	0.0424	0.0144	0.0137	0.0309	0.0011	0.1567	2.9377
HA-II-2	30	10.10.13	HA	II	u	2	0.0278	0.0100	0.0131	0.0388	0.0009	0.1712	2.7764
HA-II-3	30	10.10.13	HA	II	u	3	0.0300	0.0094	0.0107	0.0246	0.0009	0.1670	3.1785
HA-II-4	30	10.10.13	HA	II	u	4	0.0247	0.0088	0.0104	0.0289	0.0008	0.1665	2.8137
ST-C-1	86	12.12.13	ST	C	u	1	0.0444	0.0133	0.0141	0.0242	0.0009	0.1726	3.3263
ST-C-2	86	12.12.13	ST	C	u	2	0.0786	0.0226	0.0284	0.0349	0.0010	0.2083	3.4741
ST-C-3	86	12.12.13	ST	C	u	3	0.0320	0.0100	0.0136	0.0227	0.0007	0.2101	3.1937
ST-C-4	86	12.12.13	ST	C	u	4	0.0484	0.0157	0.0171	0.0273	0.0008	0.1868	3.0823
ST-I-1	86	12.12.13	ST	I	u	1	0.0654	0.0202	0.0247	0.0311	0.0011	0.2114	3.2371
ST-I-2	86	12.12.13	ST	I	u	2	0.0844	0.0254	0.0322	0.0391	0.0012	0.2167	3.3276
ST-I-3	86	12.12.13	ST	I	u	3	0.0754	0.0245	0.0325	0.0484	0.0013	0.2192	3.0820
ST-I-4	86	12.12.13	ST	I	u	4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ST-II-1	86	12.12.13	ST	II	u	1	0.0977	0.0297	0.0376	0.0501	0.0013	0.2119	3.2864
ST-II-2	86	12.12.13	ST	II	u	2	0.0338	0.0108	0.0129	0.0246	0.0008	0.1867	3.1284
ST-II-3	86	12.12.13	ST	II	u	3	0.0426	0.0138	0.0159	0.0287	0.0010	0.1864	3.0844
ST-II-4	86	12.12.13	ST	II	u	4	0.0351	0.0126	0.0076	0.0319	0.0007	0.0961	2.7861
SU-C-1	86	12.12.13	SU	C	u	1	0.0343	0.0119	0.0054	0.0259	0.0007	0.0755	2.8858
SU-C-2	86	12.12.13	SU	C	u	2	0.0291	0.0130	0.0134	0.0280	0.0013	0.1915	2.2429
SU-C-3	86	12.12.13	SU	C	u	3	0.0450	0.0135	0.0165	0.0308	0.0010	0.1848	3.3356
SU-C-4	86	12.12.13	SU	C	u	4	0.0432	0.0137	0.0126	0.0263	0.0009	0.1509	3.1530
SU-I-1	86	12.12.13	SU	I	u	1	0.0526	0.0175	0.0080	0.0438	0.0009	0.0698	3.0038
SU-I-2	86	12.12.13	SU	I	u	2	0.0343	0.0110	0.0133	0.0253	0.0008	0.1886	3.1308
SU-I-3	86	12.12.13	SU	I	u	3	0.0778	0.0214	0.0287	0.0332	0.0009	0.2169	3.6421

SU-I-4	86	12.12.13	SU	I	u	4	0.0386	0.0131	0.0058	0.0358	0.0008	0.0662	2.9502
SU-II-1	86	12.12.13	SU	II	u	1	0.0390	0.0145	0.0062	0.0285	0.0008	0.0760	2.6904
SU-II-2	86	12.12.13	SU	II	u	2	0.0337	0.0129	0.0044	0.0339	0.0008	0.0552	2.6192
SU-II-3	86	12.12.13	SU	II	u	3	0.0459	0.0149	0.0079	0.0338	0.0008	0.0834	3.0880
SU-II-4	86	12.12.13	SU	II	u	4	0.0449	0.0082	0.0073	0.0310	0.0009	0.0863	5.4824
HA-C-1	86	12.12.13	HA	C	u	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
HA-C-2	86	12.12.13	HA	C	u	2	0.0391	0.0143	0.0067	0.0319	0.0010	0.0789	2.7260
HA-C-3	86	12.12.13	HA	C	u	3	0.0215	0.0073	0.0039	0.0222	0.0008	0.0761	2.9577
HA-C-4	86	12.12.13	HA	C	u	4	0.0254	0.0120	0.0053	0.0311	0.0008	0.0770	2.1178
HA-I-1	86	12.12.13	HA	I	u	1	0.0323	0.0103	0.0050	0.0228	0.0008	0.0770	3.1367
HA-I-2	86	12.12.13	HA	I	u	2	0.0488	0.0217	0.0200	0.0280	0.0008	0.2031	2.2505
HA-I-3	86	12.12.13	HA	I	u	3	0.0155	0.0067	0.0026	0.0233	0.0007	0.0573	2.3068
HA-I-4	86	12.12.13	HA	I	u	4	0.0162	0.0053	0.0033	0.0240	0.0007	0.0726	3.0547
HA-II-1	86	12.12.13	HA	II	u	1	0.0312	0.0201	0.0101	0.0290	0.0008	0.1253	1.5491
HA-II-2	86	12.12.13	HA	II	u	2	0.0771	0.0260	0.0258	0.0465	0.0010	0.1725	2.9679
HA-II-3	86	12.12.13	HA	II	u	3	0.0193	0.0085	0.0037	0.0242	0.0007	0.0719	2.2651
HA-II-4	86	12.12.13	HA	II	u	4	0.0362	0.0116	0.0150	0.0353	0.0008	0.1805	3.1223